AERO DIGEST

AVIATION ENGINEERING

DECEMBER 1955
$1.00

IN THIS ISSUE

Ballistic Missile Powerplants
Project *Vanguard*
Strength-Weight Ratio

The New American Tradition... Be Prepared

Convair is now producing in quantity the supersonic, delta-wing F-102A. With this day-or-night, all-weather Interceptor the U.S.A.F. Air Defense Command will *be prepared* to better fulfill its mission – the discouraging of attack through the effective protection of America!

Through **engineering to the Nth power** Convair continues to *be prepared* to help assure peace and freedom by producing aircraft with the capabilities of the F-102A.

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION

Douglas YC-124B powered by four 5550 h.p. Pratt & Whitney T-34 turboprop engines.

How the Holley "hidden co-pilot" does two jobs with one handle control

Throughout the entire operational range of the new Douglas YC-124B, engine power and propeller governor setting must be precisely coordinated. This has always been a "two-handle" job but in this new airplane the job is done with a single control lever and the help of a Holley Power Control which functions like a "hidden co-pilot".

One of these controls installed on each 5550 horsepower Pratt & Whitney Aircraft T-34 engines automatically senses altitude, air temperature and speed and feeds the information to its nerve center —a series of precision manufactured 3-dimensional cams. These cams continuously interpret this information in terms of engine power which is automatically adjusted through precise metering of fuel by the control.

The Holley Power Control not only coordinates the engine and propeller for all forward thrust conditions but also controls the vital reversing of thrust necessary to reduce the aircraft's landing roll.

Designed, developed and manufactured by Holley, the "hidden co-pilot" is dependable, easy to service, compact and lightweight—four qualities that always distinguish Holley aviation equipment.

HOLLEY Carburetor Co.

11955 E. NINE MILE ROAD
VAN DYKE, MICHIGAN

LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES

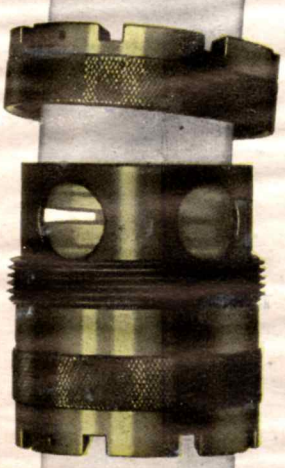
For further information circle Reader Reply No. 19

Are You Interested In WEIGHT REDUCTION?

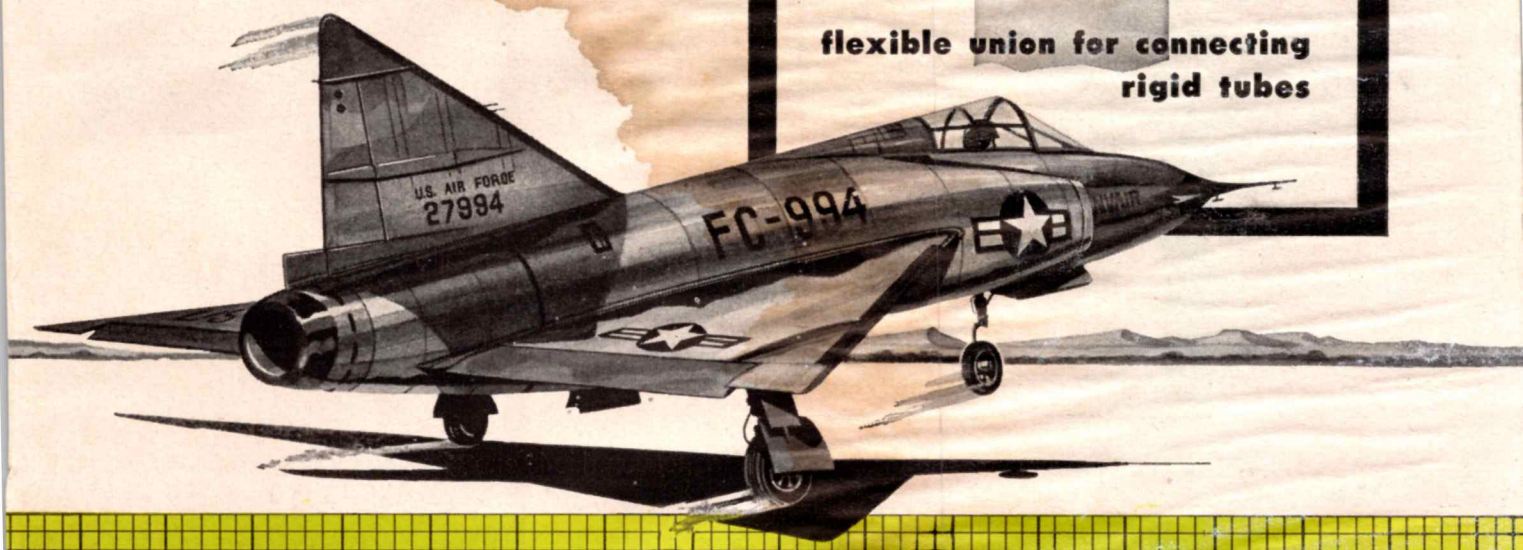
WIGGINS COUPLINGS SAVE 49 POUNDS ON CONVAIR F-102

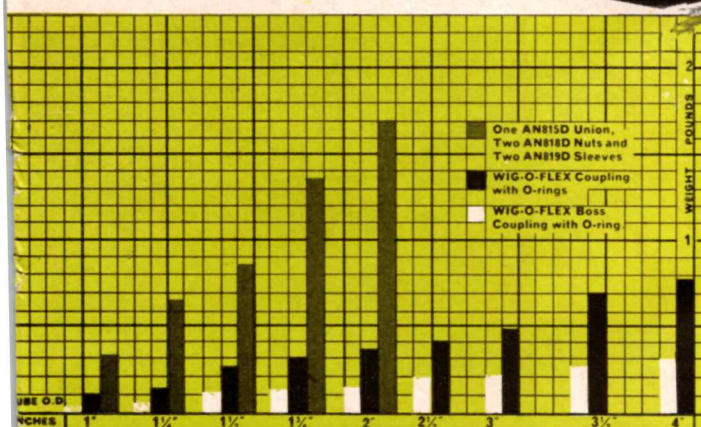
The new CONVAIR F-102 is 49 pounds lighter because WIG-O-FLEX Couplings replaced standard AN connections and cut hose. We are gratified that engineers at CONVAIR—the company that prides itself on "Engineering to the Nth power"—chose WIG-O-FLEX Couplings for a plane where weight was a major problem. The WIG-O-FLEX Coupling weighs 1/5 as much as the standard AN connection it can replace. (See weight chart for exact comparisons.)

WIG-O-FLEX COUPLING



flexible union for connecting rigid tubes





WEIGHT COMPARISON CHART
WIG-O-FLEX COUPLING & AN STANDARD FLARED TUBE CONNECTION

PROVED SUPERIOR FO FUEL, OIL, AIR

- Withstands more than 1000 psi burst pressure.
- Accommodates 4° tube flexure.
- Installs locally, 80% lighter.
- Temperature range —65°F to +250°F.

SIZES: 1"-1¼"-1½"-1¾"-2"-3"-3½"-4"

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Wiggins

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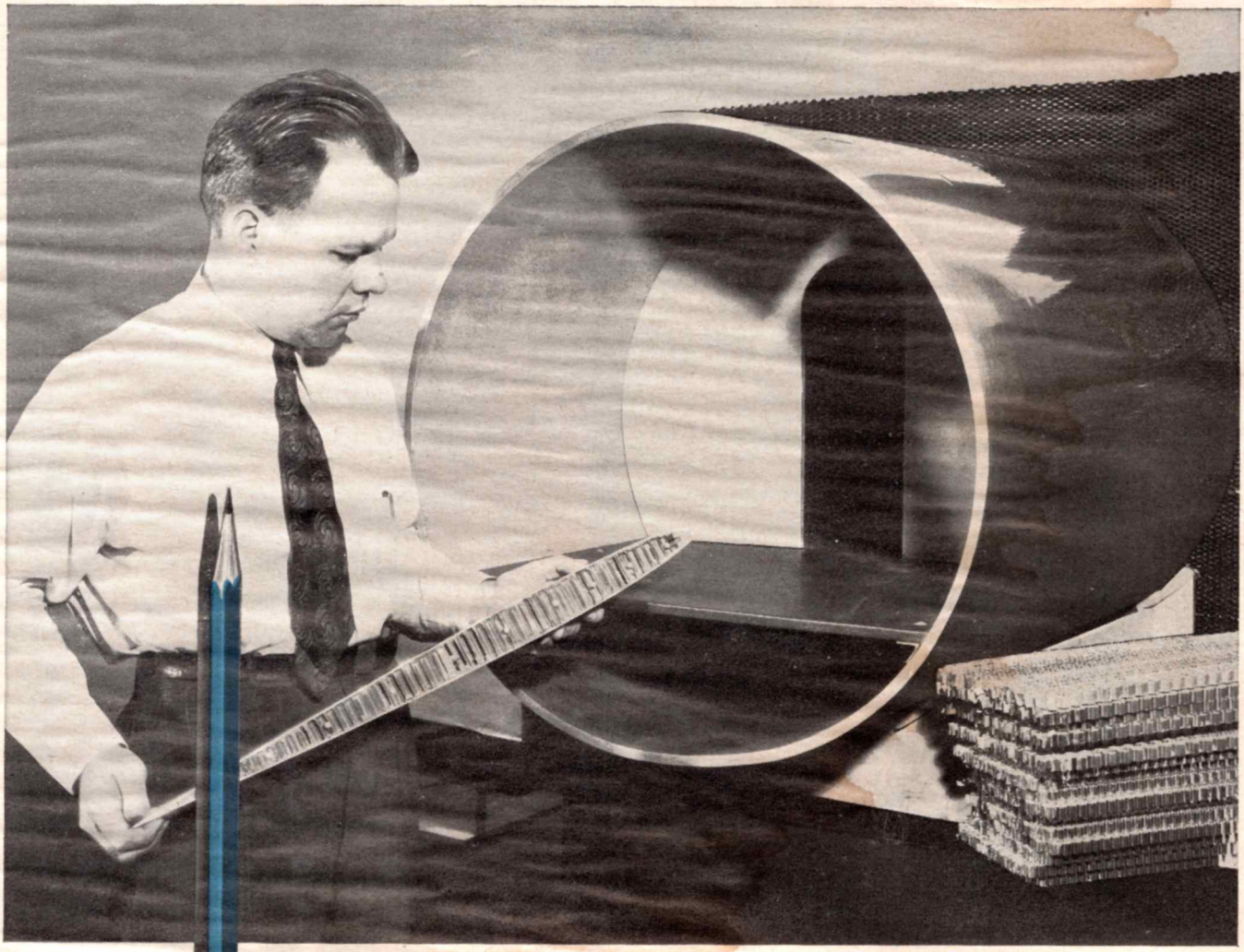

this man knows Honeycomb!

He's Ted Pajak, a pioneer in the research, development and application of aluminum honeycomb materials. Ted has more than ten years experience in the structural sandwich field and holds several of the basic patents on core and sandwich fabrication. He is one of several Hexcel engineers ready to lend their know-how to your most difficult fabrication problems. Hexcel GLASS FABRIC, COTTON FABRIC and ALUMINUM Honeycomb is available in flat sheets, pre-shaped forms and tapered sections as required, and conforms to applicable Government and aircraft specifications. If you have a problem, phone, write or wire...

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AERO DIGEST
AVIATION ENGINEERING

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Stuttgart, Germany

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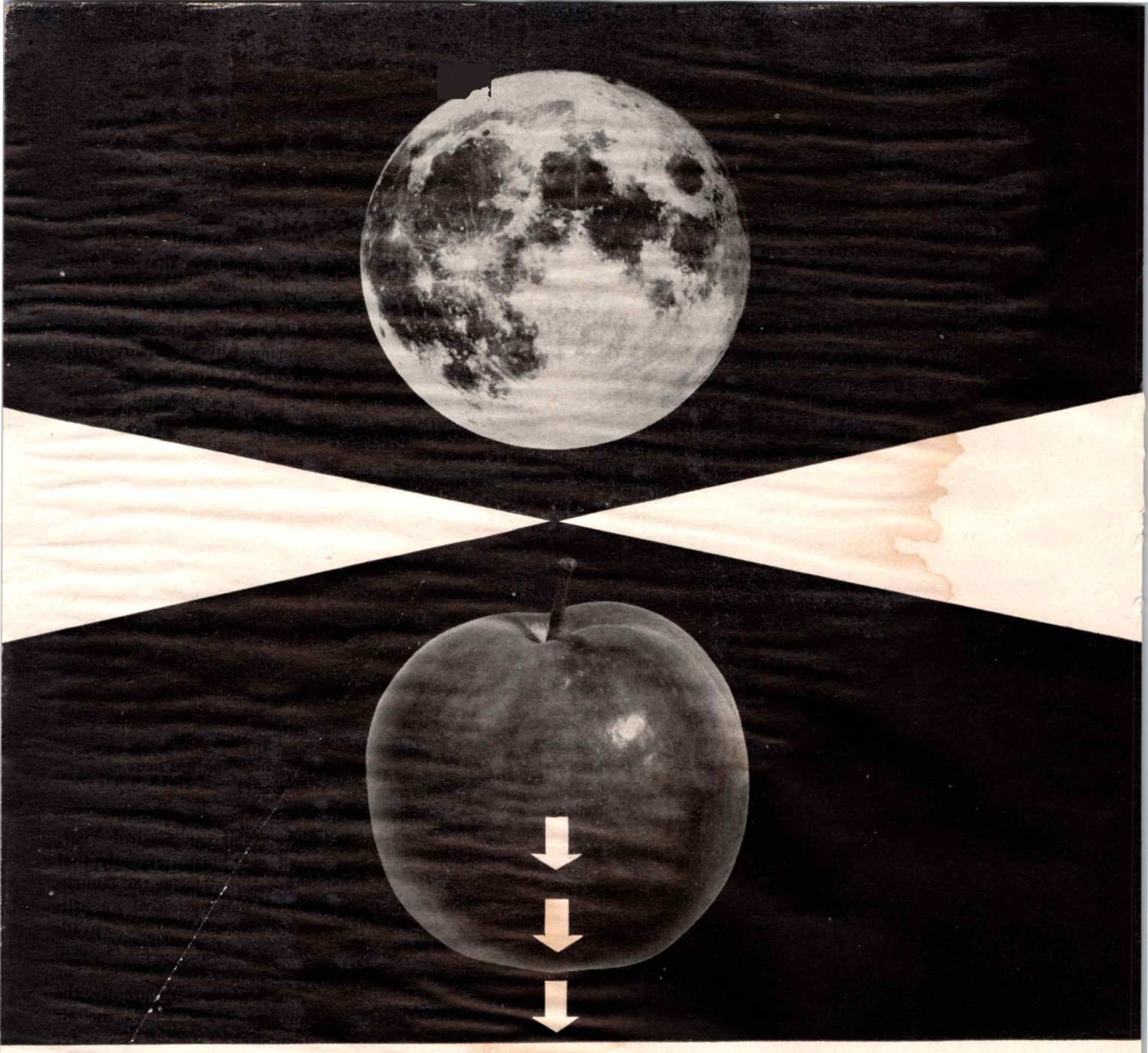

PROBLEM: GRAVITY

Interested in it? So are we!

For part of the work in advanced design at Martin includes an overall search into the basic laws of the universe—probing the unknown in every field that relates to airborne systems.

As a result of this far-reaching program of exploration—which includes the establishment of an independent laboratory for pure and advanced research—exciting new long-range developments have created exceptional opportunities at Martin on projects of the highest priority and importance.

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MARTIN
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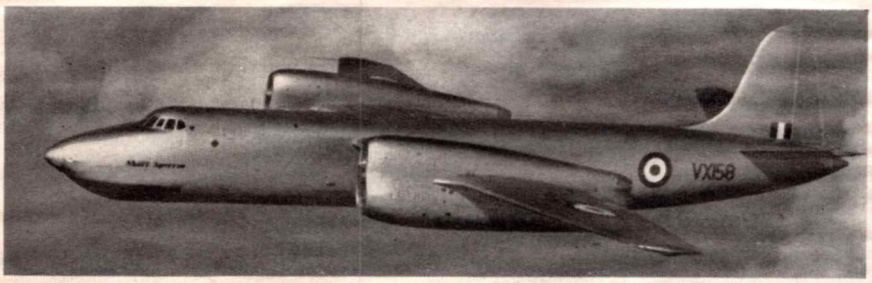
AERO NEWS DIGEST

FORTY-FIVE AEROBEES will be fired at Churchill, Canada, Thule, Greenland and in New Mexico during the International Geophysical Year, the interval from July 1, 1957 to December 21, 1958. Among the experiments to be performed will be measurement of ionospheric charge densities and the earth's magnetic field; determination of atmospheric structure, composition, and winds; auroreal and airglow studies and measurement of solar radiation. (More than a hundred smaller rockets will be fired at various locations from the equator to the polar regions in synoptic studies of cosmic rays, auroral particles and solar radiation during solar flares.) The rocket vehicle required to place the *Vanguard* satellite more than 250 miles above the earth apparently will be a design more advanced in size, multiple-staging and reliability than has been disclosed at the present time. The recent statement by the Aerojet-General Corporation that it could start immediate construction of a successful space satellite indicates significant advancements in missile developments. It has been interpreted to mean that the second stage rocket for the *Vanguard* satellite step vehicle will be a modified *Aerobee-Hi* rocket.

• • •

FIRST-STAGE ROCKET PROPULSION SYSTEM for the *Vanguard* satellite will be the fifth major engine to be designed and produced by the General Electric Company. Work on the new engine is now progressing at plants in Evendale, Ohio and Schenectady, New York. General Electric's first major rocket engine, which had a thrust rating of 16,000 pounds, was produced in 1950 for the *Hermes* A-1 missile. The thrust of the *Vanguard* engine is understood to be more than 200,000 pounds. In early 1955, the Rocket and Ramjet Section of General Electric's guided missile program became part of the Aircraft Gas Turbine Development Department at Evendale. This consolidation gives the rocket engine staff access to Evendale's multi-million-dollar development facilities.



The de Havilland *Gyron* 15,000 pounds thrust engine is mounted in the lower port nacelle of a *Sperrin* flying test bed.

• • •

THE QUESTION of whether the United States' *Vanguard* artificial satellites will be launched on time, that is during the International Geophysical Year, from July 1, 1957 to December 31, 1958, has recently been asked by many people. Rumors that the awarding of contracts for some of the basic components and for the instrumentation of the satellites has been delayed—or that they have not been executed yet—indicate that Project *Vanguard* will have to be a crash program. Says Dr. Fritz Zwicky (see page 28) about the project: "The Soviets have an excellent chance to overtake us because we are suffering from all kinds of jealousies, bureaucracies and nonsense of passing the buck. We are not in as good a position as most people think." But Milton Rosen, Technical Director of Project Vanguard says that the first satellites will be launched during the IGY. Apropos the jealousies mentioned by Dr. Zwicky, the industry is still wondering why the Army Ordnance and many of the competent and original satellite backers and experts have been neglected, and why they have not been called on to participate in the program. In spite of the fact that Dr. Joseph Kaplan, Chairman, U. S. National Committee for the International Geophysical Year, announced in Chicago recently that "the basic techniques for the launching and instrumentation of an artificial earth satellite are now available," many rocket engineers seem unconvinced that the job can be tackled successfully. Apparently, the whole project is still up in the air and the magnitude of the task is far greater than anticipated, while on the other hand, it appears that far less cooperation has been put in on it than was originally planned.

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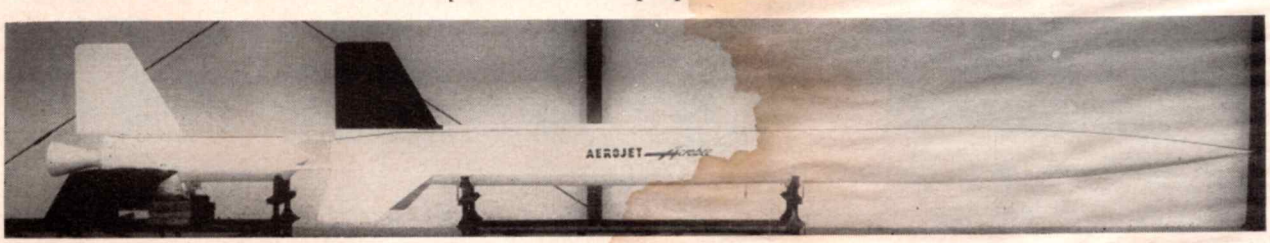
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS celebrated its diamond jubilee in Chicago last month, while the American Rocket Society cele-



A modified Aerojet *Aerobee-Hi* might be used as the second-stage vehicle for the Vanguard three-step satellite rocket.

ARO Flies With The Super Sabre*

...to first supersonic world speed record!

Just seconds after the tiny white contrail breaks into the blue, she's here and gone! Out of sight, almost, before the thunder from her jets is heard 40,000 feet below. It's the Air Force North American F-100 Super Sabre streaking into aviation's hall of fame at 822.135 M.P.H.—world's first supersonic speed record. And aboard, to protect pilot Col. H. A. Hanes, U.S.A.F., is precision-built Aro oxygen and "Anti-G" equipment.

Leading aircraft makers and the Military depend on Aro research and development for equipment to meet today's needs—and to be ready for tomorrow's. Nobody knows when Col. Hanes' record will be broken. But it's a safe bet that when it is, Aro equipment will be aboard. For details on how Aro can serve you, write:

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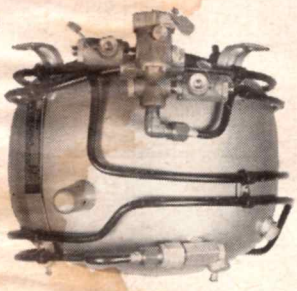
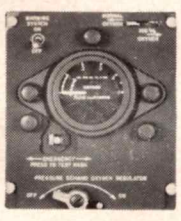
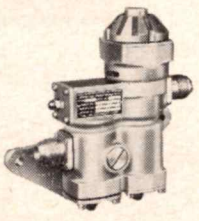


ARO Liquid Oxygen Converter — assures ample oxygen supply with big savings in space and weight. The Super Sabre carries the Aro 5 Liter Converter.



ARO D-2 Oxygen Regulator — another Aro precision instrument aboard the Super Sabre to insure safety of pilots in high-altitude flight.



ARO "Anti-G" Valves — afford protection to Super Sabre pilots against the physical strain of extreme centrifugal force.

For further information circle Reader Reply No. 3

brated its silver anniversary. The organizations held their annual meetings jointly. The ASME Daniel Guggenheim Medal was awarded to Dr. Theodore von Kármán, while the ARS Astronautics Award was given to Dr. Wernher von Braun. The Robert H. Goddard Memorial Award was presented to Lt. Col. E. N. Hall, Western Development Division of Air Research & Development Command. The G. Edward Pendray Award went to Dr. Walter Dornberger, formerly Commanding Officer of the Peenemünde rocket establishment in Germany. The James H. Wyld Memorial Award was given to Lt. Col. John P. Stapp of Holloman Air Development Center.

• • •

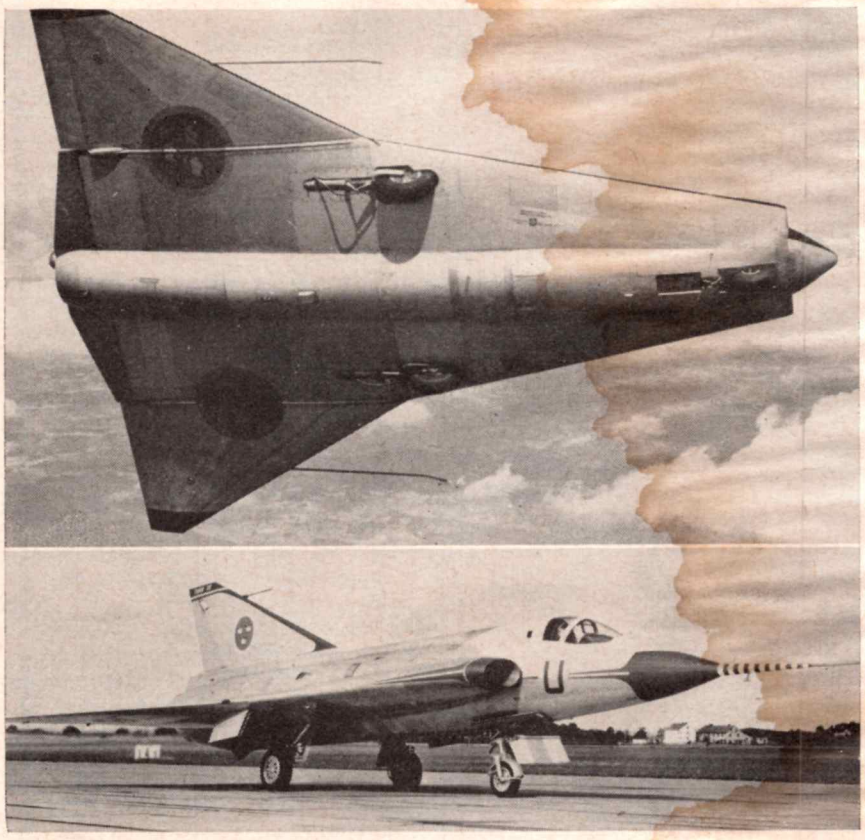
HANDLEY PAGE is laying down the necessary jigs and tools for the production of 100 *Herald* branchline transports *(AERO DIGEST, November 1955)*. This decision follows orders from Europe, Australia and Latin America. Already 35 *Heralds* have been earmarked for airline service. The prototype of this four-engined transport first flew in August; it is now engaged in an exhaustive flight-test program. Early results of these trials are said to have been excellent; they vindicate the faith of the airlines that ordered 29 *Heralds* even before the prototype flew. The *Herald* is a medium range aircraft capable of carrying 44 tourist or 36 first-class passengers, combinations of passengers and freight, or freight alone.

• • •

BENCH TESTING of the *Gyron* jet engine has been undertaken by de Havilland. Trials to gain experience in the air are being conducted with the unit mounted in the lower port nacelle of the Short *Sperrin* jet bomber. The *Gyron*, which recently passed a British Government type-approval test at an initial rating of 15,000 pounds thrust, is an engine specifically designed for supersonic flight. It is one of the most powerful jet engines in the world.

• • •

THE ARMY has decided to buy several Hiller flying platforms



The Saab-210 experimental double delta research plane (top) proved so successful that the Swedish Air Force ordered the *Draken* full-size supersonic combat fighter (bottom) in an undisclosed number to replace the Flying Barrels currently in squadron service in Sweden.

D&B RESEARCH

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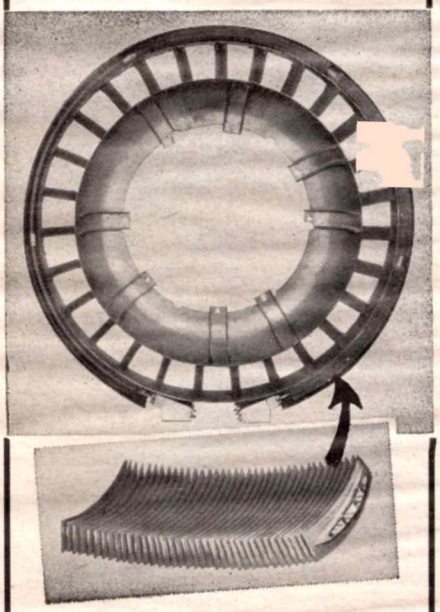

SPECIFICATIONS

MATERIAL—Extruded 63S-T2 aluminum core. Dip brazed aluminum cooling fins. No mechanical or welded joints except at entrance and exit of core.

TYPICAL PERFORMANCE—30 inch diameter cooler—Oil Flow—90 pounds/minute—Inlet Oil Temperature—220 degrees Fahrenheit—Cooling Air Temperature—100 degrees Fahrenheit—Airflow—360 pounds/minute—Outlet Oil Temperature—160 degrees Fahrenheit—Unit Heat Dissipated — 3000 B.T.U./minute/100 degrees Fahrenheit.

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For further information circle Reader Reply 12

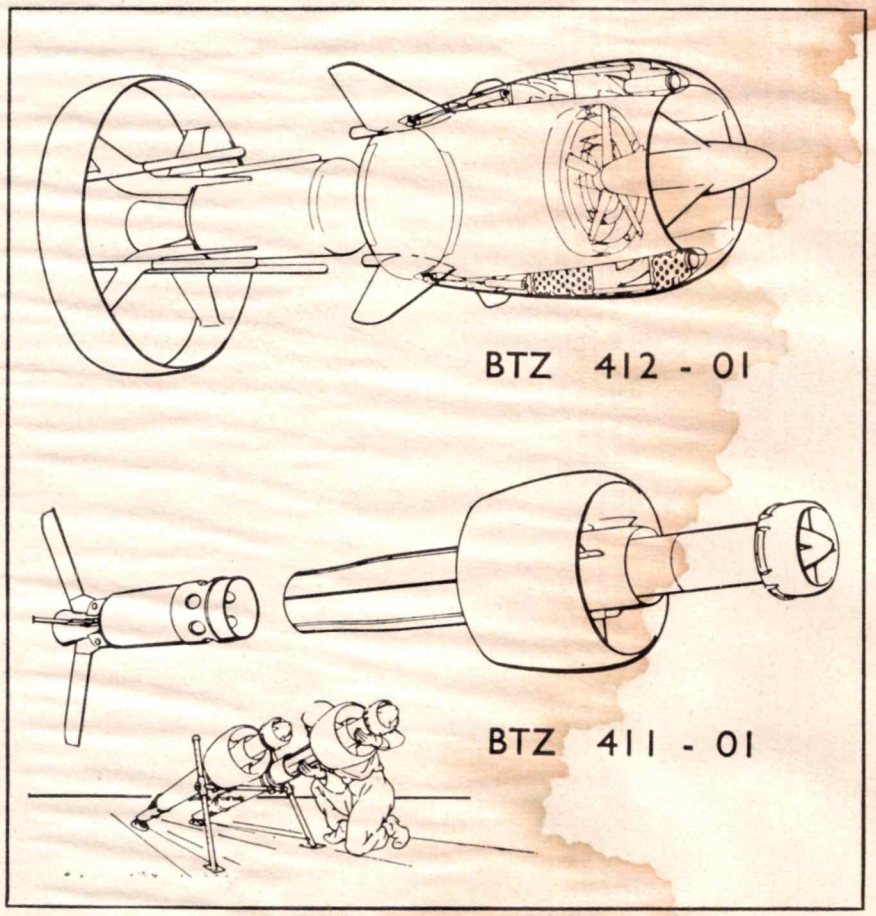
(AERO DIGEST, November 1955) to determine whether the ducted fan vehicles will give added troop mobility for the atomic battlefield. Army planners believe the small, wingless platform, now capable of carrying one man, may have many military uses, and, if the platforms pass satisfactorily, they could become jeeps of the air. Possible uses of the platform include reconnaisance, liaison and guerrilla warfare.

• • •

The French Bureau Technique Zborowski, which is responsible for numerous coleopter designs (*AERO DIGEST, June 1955*), has released two new two-stage guided missile designs, the BTZ 412-01 and the BTZ 411-01. Both missiles are sustained aerodynamically in flight by their barrel-type coleopter wings, or rings. Missile 411-01 is designed as a bazooka-type weapon. Dr. Zborowski, who designed the BMW rocket plant for the world's first rocket-powered aircraft, the Messerschmitt 163, is director of the research establishment. Among his staff members are Professor Heinrich Hertel, former Development Chief of Junkers, and aerodynamicist Dr. Wilhem Seibold. Their work is partly subsidized by the French Government.

• • •

AT THE INTERNATIONAL Congress of Mathematicians at Heidelberg in 1904, Ludwig Prandtl in a lecture founded the theory of boundary layers. That was over 50 years ago. Today leading scientists from all parts of the world are preparing an Anniversary Volume in honor of Prandtl's work. An impressive study is resulting with original contributions covering the following studies: laminar boundary layer flows of incompressible and compressible fluids, stability of laminar flows, turbulent boundary layer flows, boundary layer control, and thermal boundary layers and related problems. It is expected that this volume will not only contribute to the state of the art but also will stimulate further developments in boundary layer research.



French coleopter missiles, BTZ 412-01 and BTZ 411-01, designed by Bureau Technique Zborowski

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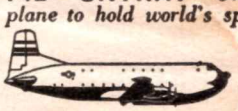
F4D "SKYRAY" *Only carrier plane to hold world's speed record*



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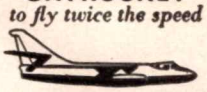
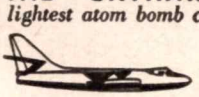
NIKE *Supersonic missile selected to protect our cities*

"SKYROCKET" *First airplane to fly twice the speed of sound*



A3D "SKYWARRIOR" *Largest carrier-based bomber*

A4D "SKYHAWK" *Smallest, lightest atom bomb carrier*



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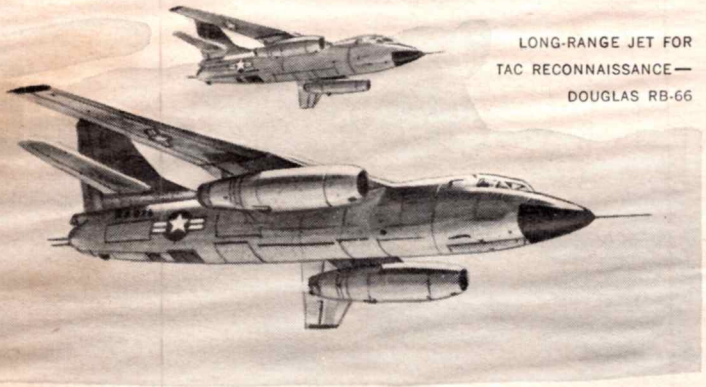


LONG-RANGE JET FOR TAC RECONNAISSANCE— DOUGLAS RB-66

Defense is everybody's business

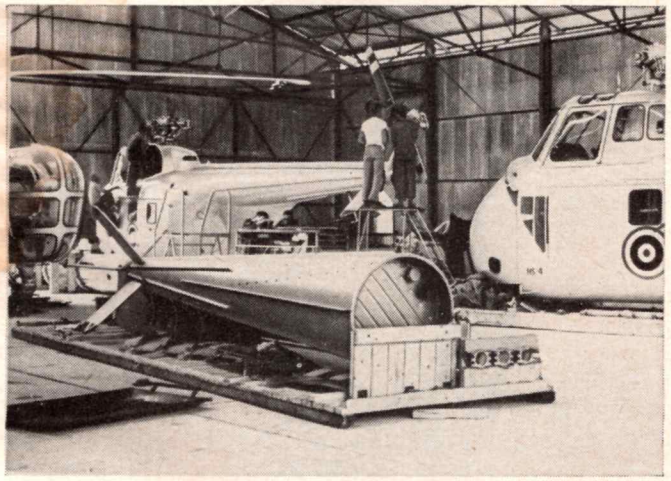
The Douglas RB-66 can fly 600-700 mph but not without people to pilot and service it. The Air Force needs young men and women who agree that "defense is everybody's business."

Depend on *DOUGLAS* **First in Aviation**

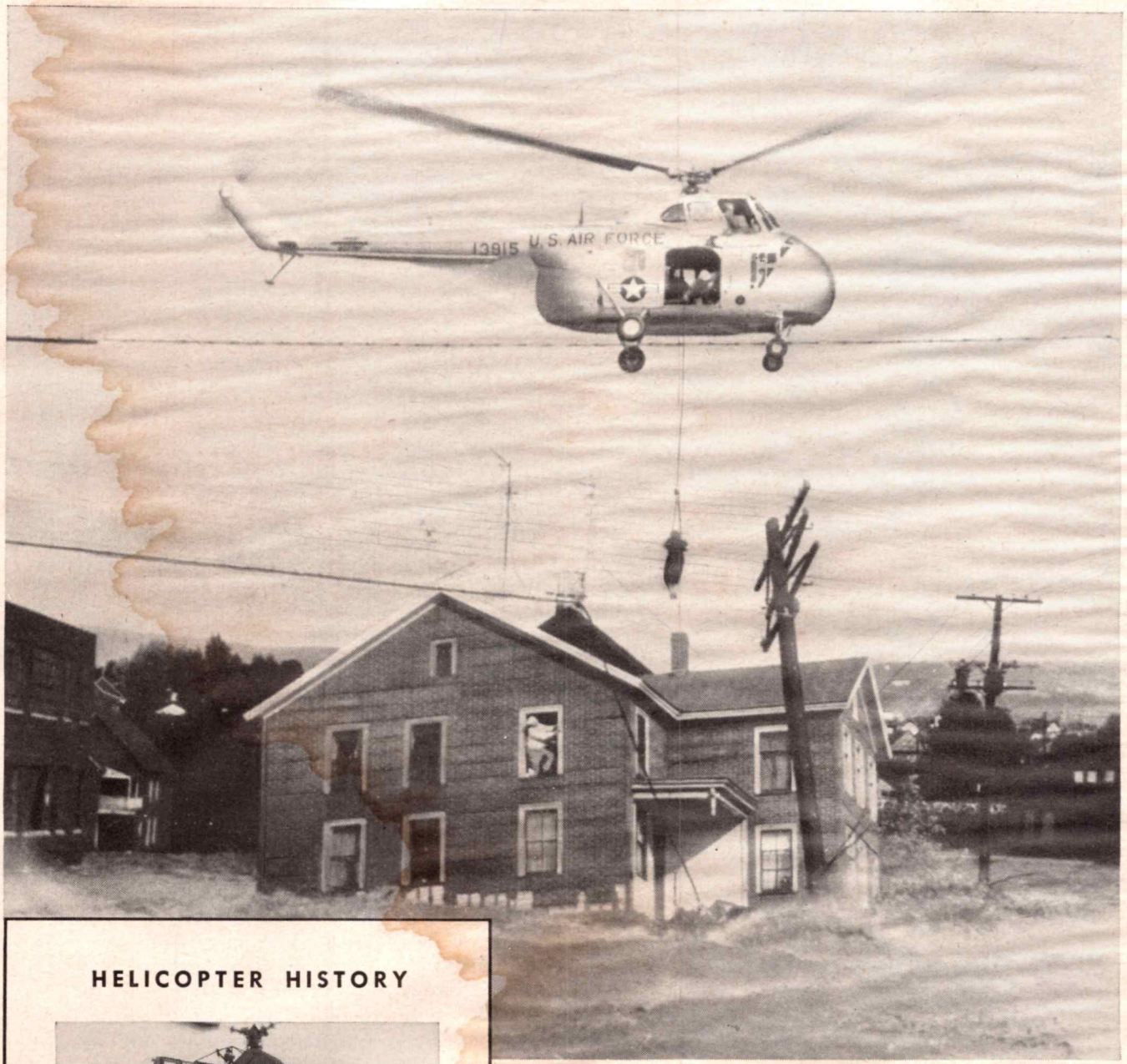
FLIGHT TESTING THE ANTI-SUB HSS—At Patuxent River, Maryland, the Navy has subjected the HSS helicopter to carefully-instrumented, grueling tests. This submarine-hunter is one version of the high-performance Sikorsky S-58. It uses electronic sonar gear to locate and track subs. Addition of arming racks enables it to launch torpedoes or mines. The S-58 has twice the payload capacity of the S-55. Rotor blades fold back for shipboard use.

AROUND THE WORLD WITH SIKORSKY HELICOPTERS

FOR VENEZUELA—A new Sikorsky S-55 type helicopter, pictured above, has been delivered to the Venezuelan Air Force. With the delivery, Venezuela joined the ranks of 14 nations whose armed forces or commercial air operators rely upon the efficiency and dependability of versatile Sikorsky helicopters. Pilots were trained in the S-55 at Sikorsky's Bridgeport plant.



FOR THAILAND—A representative of United Aircraft Service Corporation supervises the assembly of Sikorsky S-55 type helicopters in Bangkok. The machines will be flown by the Royal Thailand Air Force, on low-level border patrol duty. Six of the big Sikorsky helicopters were ordered. The type has achieved an outstanding record operating in jungles and other remote areas.

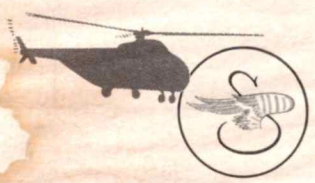


HELP FROM THE SKY—When flash floods hit the northeastern states in late August, helicopters picked up nearly a thousand people and carried them to safety. People were rescued from houses being torn to pieces by savage flood waters, from hilltops, and from stranded trains and cars. In Connecticut alone, more than 500 were saved by Sikorsky helicopters. Above, a USAF Air Rescue Service Sikorsky H-19, pictured in Pennsylvania, lifts a woman to safety as a man waits his turn at a second floor window. Helicopters were often the only means of rushing food, medicine, and rescue workers to the stricken areas.

HELICOPTER HISTORY

FIRST HELICOPTER AIR-SEA RESCUE

In November, 1945—almost ten years before the recent flood disaster in which Sikorsky helicopters saved hundreds of people—a Sikorsky R-5 made what is believed to be the first helicopter rescue. Crewmen were brought safely ashore from a storm-swept barge wrecked on Penfield reef, off Fairfield, Connecticut.



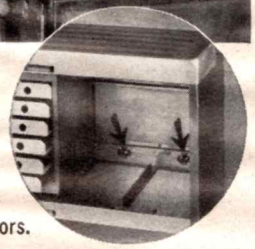
SIKORSKY AIRCRAFT

BRIDGEPORT, CONNECTICUT

One of the Divisions of United Aircraft Corporation

For further information circle Reader Reply No. 42

Hot coffee... hot soup... and hot plates... must be hot. No if's, and's, or but's. But to be sure they are... always use Cannon Buffet Unit Connectors.



All the Airlines use CANNON BUFFET UNIT CONNECTORS

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16534

BUC-6-33

Write TODAY for Bulletin BU-1, Buffet Unit Connectors.

...just the type you need!

13033

40th YEAR 1915-1955

Please refer to Dept. 103

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For further information circle Reader Reply 9

The work is to be published by Friedr. Vieweg & Sohn, Braunschweig, Germany.

• • •

SWEDEN'S Saab Aircraft Company recently test flew the new supersonic J-35 *Draken (Dragon)*. The plane was designed and built for the Royal Swedish Air Force and is a single seater capable of attaining a high supersonic Mach number in level flight. It incorporates the double delta design, an advanced configuration developed exclusively in Sweden and tested during the past two years on the company's tiny Saab-210 jet research plane. This unique design provides a relatively large space for equipment and fuel in combination with low weight and low drag at supersonic speed. The air intakes are built into the inner wings in such a way that the fuselage nose boundary layer air is led past the air intakes, providing a high degree of intake efficiency. Combined elevator and ailerons are fitted to the trailing edges of the wings; the plane thus lacks a conventional tailplane. The fin also has a delta form and continues forward to the cockpit in a low spine, containing various control lines, which are thereby made easily accessible. The cockpit is pressurized and is fitted with Saab's latest type fully automatic ejection seat. All flying controls are servo-operated. The landing gear is a tricycle type with an unusual design feature; the shock absorbers of the main gear are shortened during retraction to reduce the space required for the main gear in its retracted position. A braking chute is fitted in a container beneath the fin and greatly reduces the plane's landing run. The craft's main armament consists of an unspecified number of cannon and it can also carry rockets and guided missiles. Electronic equipment permits all-weather navigation and flight at high altitudes. Powerplant is a Rolls-Royce *Avon* turbojet with afterburner. The engines will be built under license in Sweden by Svenska Flygmotor AB. The new Saab-35 will gradually replace the earlier Saab-29 *Flying Barrels*, in service since 1951. It has been designed and built in collaboration with the Royal Swedish Air Board and wind tunnel tests were carried out at the Aeronautical Research Institute of Sweden at Ulvsunda, at Saab in Linköping, at the Royal Institute of Technology in Stockholm and at Svenska Flygmotor AB in Trollhättan. Saab Aircraft reports that altogether, approximately 500 technicians and engineers were engaged in the development of the Saab-35.

• • •

A half-page advertisement in a recent issue of the German aeronautical magazine *Flugwelt* (Flying World) reads as follows: Messerschmitt is prepared for the forthcoming aircraft manufacturing tasks.

• • •

BRITISH EUROPEAN AIRWAYS is in negotiation with Vickers-Armstrongs Ltd. for a fleet of Vickers 900 *Vanguard* airliners designed for delivery in 1959/60. The Vickers *Vanguard* — or Vickers 900 — will be a 93-passenger airliner powered by four Rolls-Royce R.B. 109 propeller-turbine engines. It is being designed to meet a detailed BEA specification of requirements drawn up by the company earlier this year as a result of two years detailed analysis and discussion. This BEA requirement calls for an airliner that "will set a new world standard in its class and will be ahead of all known competition in reliability, speed, economy, comfort, pilot handling, maintenance characteristics, ability to make quick turn-arounds and in general passenger appeal." The specification supplied by BEA to Vickers is believed to be the fullest statement of detailed requirement ever given by an airline operator to a manufacturer and runs to more than 50 pages. Throughout the design period there has been the closest possible co-operation between BEA and the manufacturer.

ERIK BERGAUST

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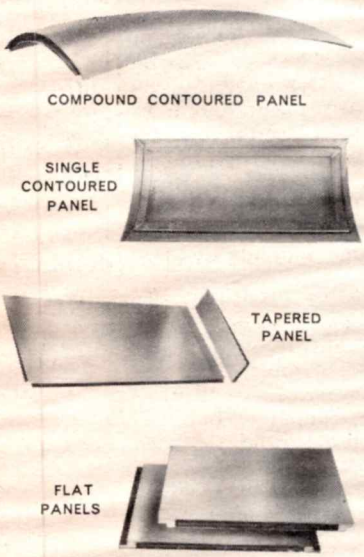
For example, to meet the demands for high-strength, light-weight, heat-resistant material for which aircraft designers are searching, ROHR is developing all-metal, honeycomb, sandwich structures.



When you want aircraft parts better, faster, cheaper . . . call on Rohr and the Rohr engineering skill and production know-how gained from building thousands of power packages and millions of other aircraft parts.

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CHULA VISTA AND RIVERSIDE CALIFORNIA

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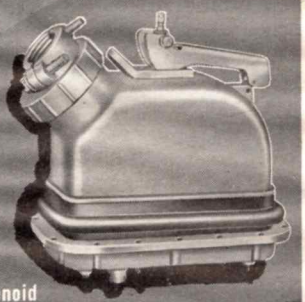
40th YEAR 1915-1955 CANNON ELECTRIC

Cannon quality
in missile
launching connectors
means safety



GMA–Solenoid or Manual Release. 41 to 140 Contacts. Coaxials Available.

GMJ–Skid Away Release. 18 Size 14 Contacts.

GMD–Skid Away Release. 22 or 50 Size 14 Contacts.

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AVIATION ENGINEERING

PUBLISHED BY THE AERONAUTICAL DIGEST PUBLISHING CORPORATION

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EXCLUSIVES IN AERO DIGEST

for January

- **Canadian Aeronautical Engineering**

  Flying saucers, missiles, combat aircraft and electronic equipment marked "Made in Canada" are setting new bench marks in achievement. Just how high is told in an exclusive AERO DIGEST survey of the mushrooming Canadian aviation industry.

- **Do We Need the Pilot?**

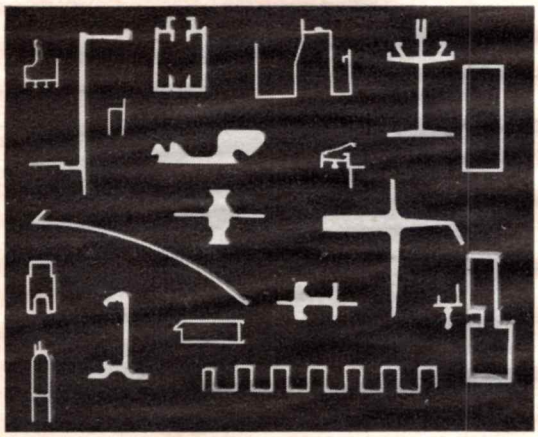
  With the automatic navigational equipment available today, the pilot may soon be obsolete. Three ground position indicators are analyzed by their inventors.

DON'T MISS

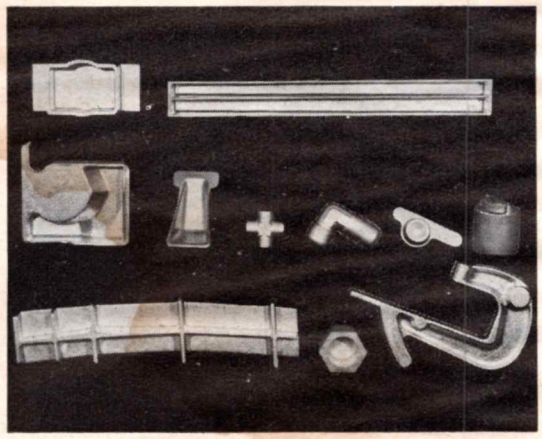
These and other exclusives — plus regular features — in the January 1955

AERO DIGEST

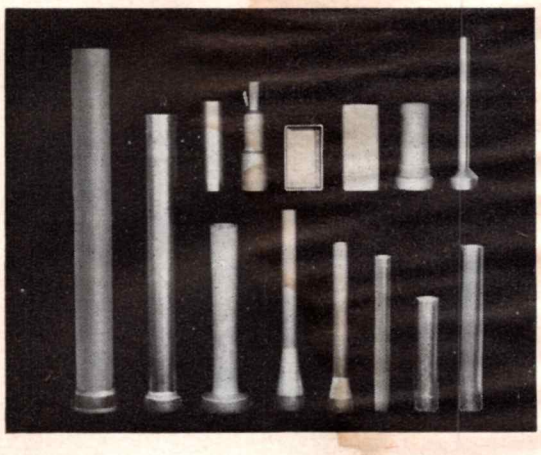
You can make it faster and better with Harvey Aluminum



EXTRUSIONS . . . For decorative as well as basic parts, custom-designed aluminum extrusions replace riveted and welded assemblies . . . simultaneously adds strength, simplifies fabrication.



PRESS FORGINGS . . . Where parts must combine maximum strength with savings in weight, cost and manpower, Harvey aluminum forgings often completely solve the problems encountered by the designer.



IMPACT EXTRUSIONS . . . Thin-walled, tubular structures can be produced by this method and held to very close tolerances. Machining is practically eliminated; scrap is greatly reduced.

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FORGING STOCK . . . If you make your own forgings in quantity, Harvey extruded forging stock can save many intermediate steps. Custom-designed extrusions whose cross sections approximate the forged blanks may be cut to length.

EXTRUDED PIPE AND TUBE . . . Seamless . . . uniform in structure, size and shape . . . clean and smooth inside and out . . . easily formed. Usable in applications ranging from portable irrigation systems to aircraft heat exchangers.

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SCREW MACHINE PRODUCTS . . . The West's largest installation of multiple-spindle screw machines can reduce your manufacturing costs. Harvey carries your job through from engineering to quality control.

Harvey is a leading independent producer of aluminum extrusions in all alloys and all sizes, special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tube, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

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HARVEY Aluminum

HARVEY ALUMINUM SALES, INC.
TORRANCE, CALIFORNIA
BRANCH OFFICES IN PRINCIPAL CITIES

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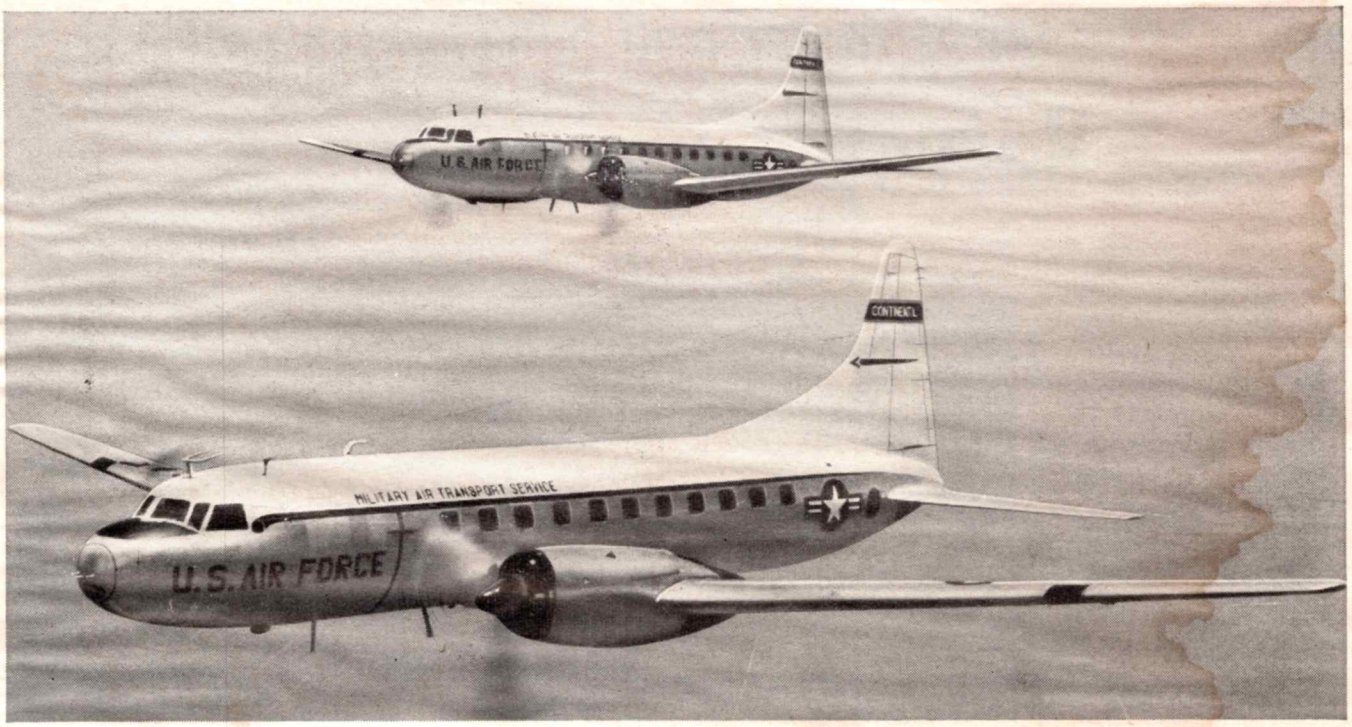

MATS Beats Flight Program Schedule with Allison Turbo-Prop Engines and Aeroproducts Propellers

To MATS' 1700th Test Squadron – Congratulations for a good job well done.

This month, the final hour will be flown on a program which has as its target 3000 flight hours by January 30, 1956 on two Convair YC-131C aircraft powered with Allison Turbo-Prop engines and Aeroproducts Propellers. The program will be completed more than 30 days ahead of schedule – thanks to the skill and enthusiasm of the pilots and crews who were given the job to do.

The aircraft were delivered to MATS at Kelly AFB, San Antonio, Texas, in January, 1955. The 1700th Test Squadron had just been activated and was composed of men who not only were outstanding in their abilities but who demonstrated a genuine enthusiasm for Turbo-Prop transports in military aviation.

Colonel Claude Smith, Commander 1700th Air Transport Group, and his staff immediately initiated a familiarization program for all personnel and the entire squadron set out to obtain maximum time on the two aircraft. The object was to prove the place of turbo-prop-powered transport in military aviation.

Hours on the aircraft mounted rapidly. Sometimes the planes shuttled between Kelly AFB and Travis AFB, or to Andrews, or to the Allison plants in Indianapolis. And many days went by with pilots making operational flights over Texas. Three and four flights a day with five hours per flight became routine. And in one 24-hour period, each aircraft was kept in the air for 23 hours and 10 minutes.

It was long, hard work for pilots in the air and crews on the ground. But they kept at it – determined not only to beat their schedule but to demonstrate convincingly to others the firm, determined faith they have in the future of turbo-prop power.

Under Lt. Col. Samuel C. Burgess, Commander, the work of the 1700th Test Squadron will continue with other aircraft powered with turbo-prop engines. But the pioneering phase of the program is concluding. The rest of the program has been aided immeasurably by the experience gained with the first aircraft assigned to the project.

We at Allison salute the good work of the men of the 1700th Test Squadron. We are proud to have been part of the project. You have proved that turbo-prop engines and propellers are "ready to go" and we are gratified that the convincing demonstration was made with Allison Turbo-Prop engines and Aeroproducts Propellers.

ALLISON
TURBO-PROP ENGINES

Allison Division of General Motors
Indianapolis, Indiana

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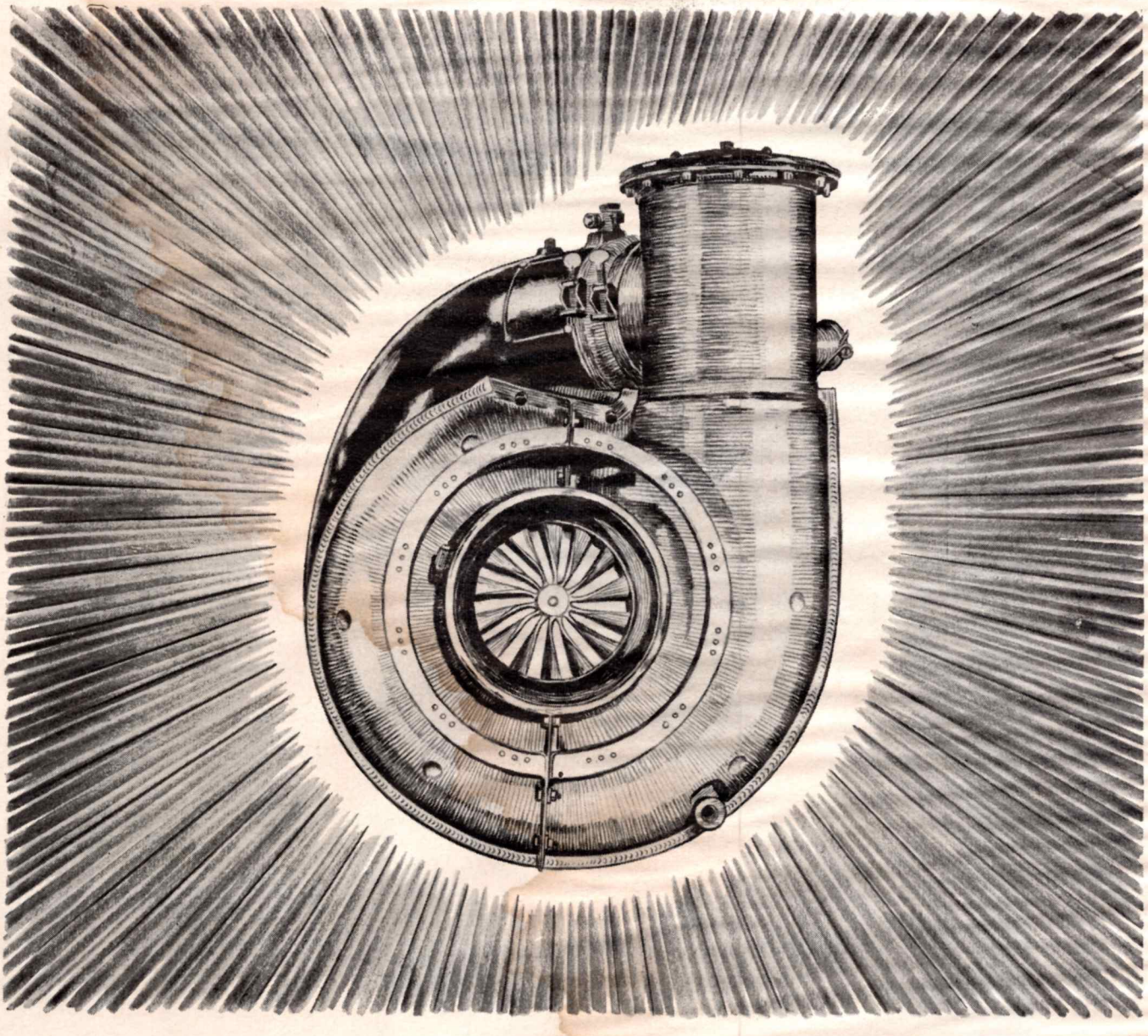
POWER PLANT OF THE FUTURE



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THE SIMPLEST PRACTICAL fuel-burning engine yet constructed is shown above. It is the Solar Mars 50 hp gas turbine. It weighs less than 100 lb and fits in a two-foot cube. It operates on a variety of fuels. Its construction is simple. And the ruggedness of the Mars engine has been proven by many thousands of hours of trouble-free service.

The Mars is a constant speed engine for emergency or stand-by duty where fuel consumption is not of primary importance. Your forward planning should include the Mars gas turbine. For detailed information about this power plant of the future, write today to Solar Aircraft Company, Dept. B-94, San Diego 12, Calif.

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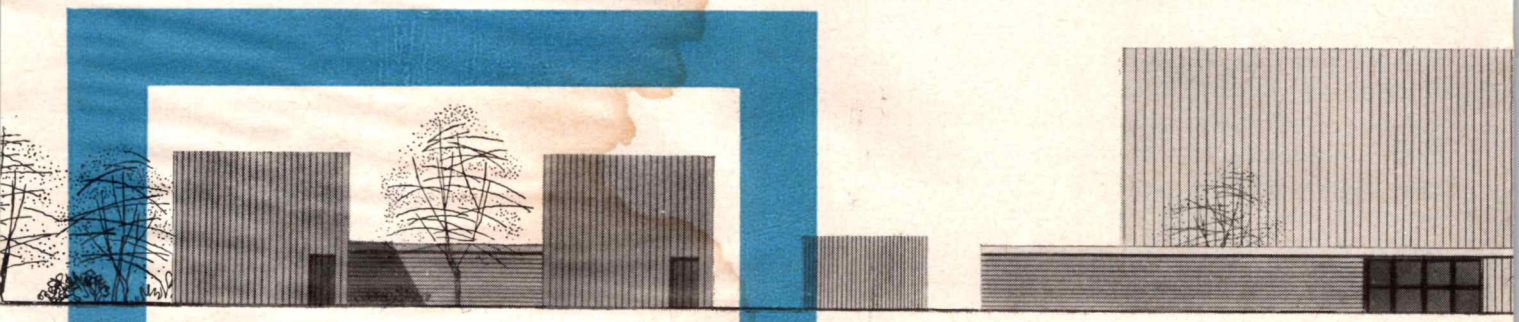
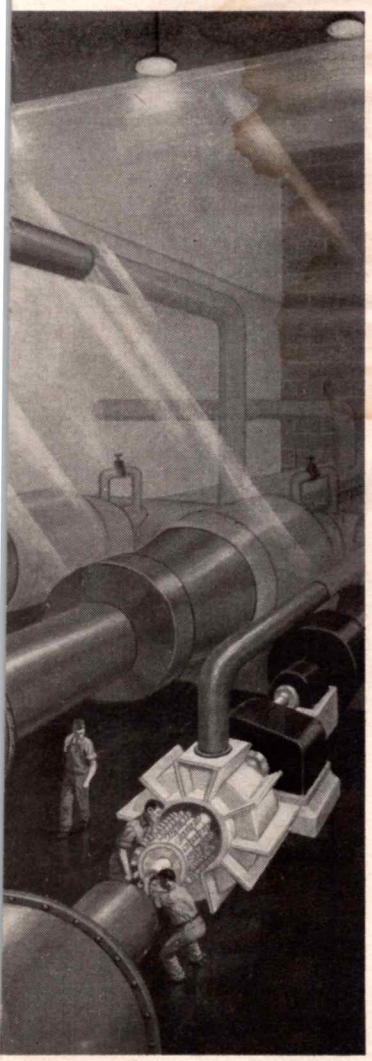
Advanced turbine



research laboratory



Power is basic to America's future in the air. Whether for small executive aircraft, short or long haul jet transports, fighters, trainers, missiles or other air weapons for free world defense . . . development of new powerplants sets the pace for progress.

Fairchild has taken the lead in the development of the small turbo-jet engine. An entirely new jet engine family has been created in its J44 . . . a package of power delivering higher thrust per pound weight.

Late this year, Fairchild Engine Division's new Turbine Research Lab will be completed and ready for action, armed with the newest engineering and manufacturing facilities and ready to serve America's best interests.

From its small beginning at Farmingdale, L. I. in 1928, Fairchild Engine Division's record has been one of constant growth and progress. This new facility, completely integrated for the latest powerplant manufacture, may be counted on in 1955 and the years to come to continue, as always, with *more power* with *less weight* in *smaller engines* to advance tomorrow's military and commercial aviation progress.

ENGINE AND AIRPLANE CORPORATION

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*Engine Division**

DEER PARK, LONG ISLAND, NEW YORK

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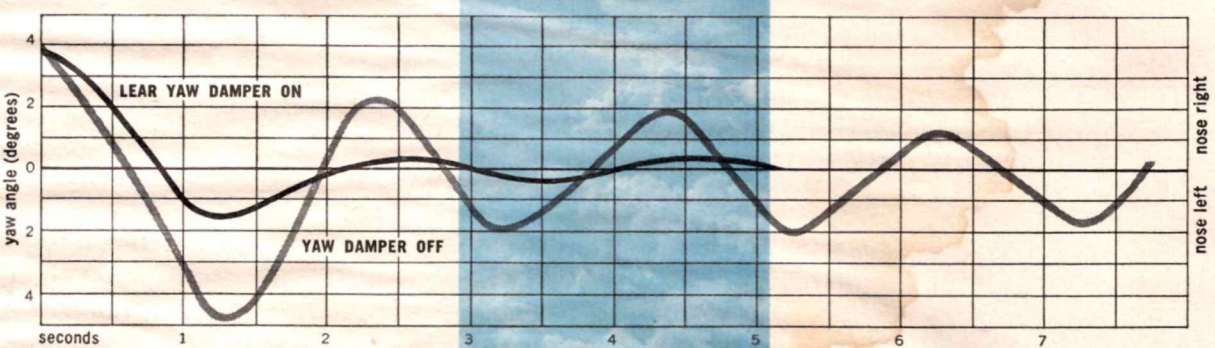
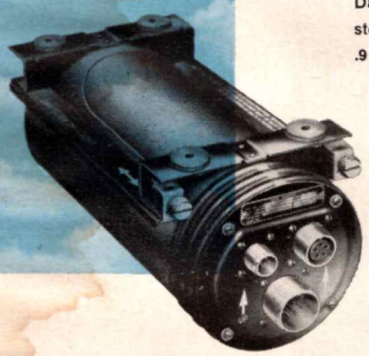
"where the future is measured in light-years"



The NAA data presented here show the difference in damping time between Lear Yaw Damper "off" and Yaw Damper "on" operation, starting from steady side slips with full rudder, at .9 Mach number, altitude 40,000 feet.



to increase "kill" probability

Weapon system design combines many arts for the purpose of annihilating the enemy. The spectacular stabilizing effect of the Lear Yaw Damper on the flight path of the F-86D Sabre is shown in the above curves prepared by North American Aviation, Inc., for the enlightenment of fighter pilots. "From these data," says NAA, "it is clearly seen why the yaw damper is an essential device to make your airplane a more effective and efficient rocket firing platform."

LEAR *Grand Rapids Division / Grand Rapids, Michigan*

IP-8

LEAR PITCH, ROLL, AND YAW DAMPERS ARE AVAILABLE IN ELECTRONIC, MAGNETIC, AND TRANSISTORIZED VERSIONS, ENGINEERED TO THE PERFORMANCE OF THE CENTURY SERIES FIGHTERS

AERO DIGEST

GUEST EDITORIAL

ASTRONAUTICS

Volume 71 Number 6
December 1955

AERONAUTICAL PEOPLE are pleased that billions spent on defense have helped develop fast, safe and closely spaced airways over this globe. They are also proud of their sounding rockets sent out on research missions to the extreme strata of our atmosphere, bringing great benefit to many disciplines of human science.

Along the same line, two new and important events have occurred: the announcement of the construction of artificial satellites; and the invitation to all nations to cooperate on the scientific problems involved—each made possible through developments in intercontinental missiles.

The fraction of aeronautical developments available to civil science and for commercial purposes is still small compared with that available to defense. Yet the portion accorded to civilian use has grown steadily in the past decade; and seems to keep growing at the same rate as the military-backed intercontinental missile development.

It is a strange historical phenomenon that the development of intercontinental missiles—of their powerplants and airframes as well as their instruments and warheads—has proved to be a passing into astronautics from aeronautics, along a devious and intricate, but effective path.

Humanity may soon be in the dilemma of declaring war nonsensical—not only on moral, but also on technical grounds—and at the same time trying to avoid dropping the gigantic defense organizations of research and industry, as well as the military establishments.

It is a stranger phenomenon that the most natural way out of this dilemma seems to be astronautics, to which we are willing neither to attach a civilian nor a military label, yet which, at any instance, will not have to do with war.

Astronautics will far better satisfy the urge for adventure, for discharging vitality, for reaching new horizons, than does our present-day military aviation.

Astronautics will require research institutes, industries and military organizations for its implementation. Yet, by this virtue, astronautics will accomplish cultural tasks instead of threatening humanity.

Looking into the future, we see ramjet liners linking terrestrial continents in a matter of hours; we see chemical fuel rockets used logistically in building artificial satellites; we see nuclear rockets on interplanetary research missions—and one day we may even see photon rockets speeding across the farthest reaches of the universe.

To accomplish these tasks, efforts of individual nations will not suffice. We shall require sound development programs employing the best scientists and the best engineers. In addition, we need a space minded civilization.

DR. EUGEN SÄNGER, Director
Research Institute for Physics of
Jet Propulsion, Stuttgart, Germany

Controlling

BALLISTIC MISSILE POWERPLANTS

During Static Firing and Airborne Operations

For simple powerplants, control by orifices or tank arrangement may be adequate. For more complex powerplants or where extended data are needed, automatic controls should be used.

RUDOLF H. REICHEL, Rocket Development Engineer
Bell Aircraft Corp., Buffalo, N. Y.

CONTROL OF BALLISTIC missile powerplants is needed to maintain optimum operating conditions during a run. Such control is vital for flight missiles as well as for static firing tests. For applications to simple missiles, it is possible to use orifices or special propellant tank arrangement. Where a more complex control is desirable as for long range missiles, control by automatic devices may be needed. For static firing tests, automatic control results in better accuracy, and improves the flexibility of the test facilities.

Adjustment methods and automatic control are influenced chiefly by the following considerations:

1) The combustion chamber pressure P_c has to be constant, or varied according to a predetermined thrust characteristic.

2) The propellant mixture ratio r must be maintained.

3) The propellant feed system as well as the combustion process must remain stabilized.

4) Manufacturing tolerances of components must be seen in the light of the entire system.

Symbols

A = area of the top or open surface of the oxidizer or fuel in the tank
A_{ex} = exit area of the De Laval nozzle
c = effective exhaust velocity
c^* = characteristic exhaust velocity
C = multiplication factor for the acceleration of gravity
D = drag force of the missile at time t
F = thrust force at sea level
ΔF = thrust augmentation effected by the variable atmospheric pressure depending on the altitude
g = acceleration of gravity at sea level
h = height of the oxidizer or fuel liquid level over the injector at time t
h_o = height of the oxidizer or fuel liquid level over the injector at launching
I_{sp} = specific impulse
m = propellant mass flow rate
m' = oxidizer or fuel mass flow rate
M = $M_o + M_p$ = gross mass
M_o = empty mass of the missile
M_p = total propellant mass
M_t = missile mass at time t
P = injection pressure
P_a = atmospheric pressure
P_c = combustion chamber pressure
P_{ex} = De Laval nozzle exhaust pressure
ΔP = augmentation of the oxidizer or fuel injection pressure effected by the influence of missile acceleration
ΔP_f = augmentation of the fuel injection pressure effected by the influence of missile acceleration
ΔP_{ox} = augmentation of the oxidizer injection pressure effected by the influence of missile acceleration
ϕ = angle of missile axis with horizontal
r = propellant mixture ratio (oxidizer/fuel)
ρ = average density of the propellant combination at sea level
ρ' = density of oxidizer or fuel at sea level
∂ = Q/M_o = design quality factor, where Q = propellant tank volume
t = time (combustion time)
v_h = velocity of the drop in the oxidizer or fuel liquid level, per unit time
V = performance criterion of the propellant with respect to the entire rocket system

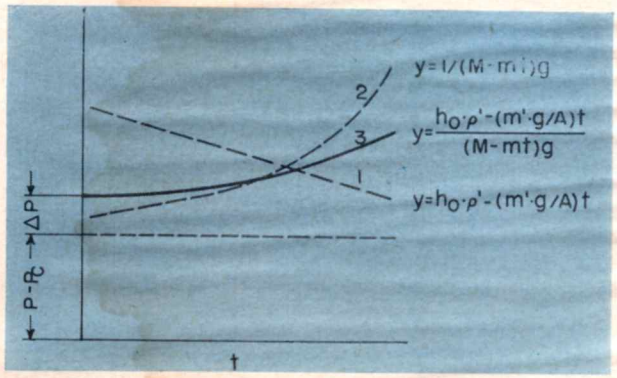


Figure 1 — Simultaneous effects on injection pressure of diminishing tank head and increasing missile acceleration.

5) Considerable improvement of powerplant operation is possible.

6) For static firing tests, it is desirable to hold constant the parameters such as combustion chamber pressure and mixture ratio, or to vary them according to a predetermined program.

• • Parameters

Performance of a rocket motor can generally be expressed by the specific impulse $I_{sp} = c/g$. This criterion of merit has value only in the event that the same propellant combination is used, because the propellant density ρ is not considered. Complete consideration of ρ follows only when all design parameters are included. For propellant comparison purposes, the equation $V = c \ln(1 + \rho\sigma)$ can be used, (Reference 1).

To control I_{sp} one must measure the thrust F, and the propellant mass flow rate m. For volume measurements, the propellant density variations must be considered. Because the thrust is nearly proportional to the combustion chamber pressure, for some purposes it is simpler to determine P_c, rather than F, by means of pressure measurement. For a ballistic rocket, where P_c is taken as the control variable, the thrust changes with altitude according to the relation $\Delta F = A_{ex}(P_{ex} - P_a)$. For control purposes this variation in thrust has to be considered.

Dependent variables are:

1) Oxidizer mass per unit time.
2) Fuel mass per unit time.
3) Propellant mixture ratio.
4) Thrust.
5) Combustion chamber pressure.

Independent variables are:

1) Orifice areas for the oxidizer; the fuel system comprising supply lines. cooling passages, and injection system.
2) The volume of the combustion chamber as well as the throat area of the De Laval nozzle.
3) Density of propellant components as well as their characteristics.
4) Atmospheric pressure with respect to the exit area of the De Laval nozzle.

For a powerplant with a turbine pump unit there

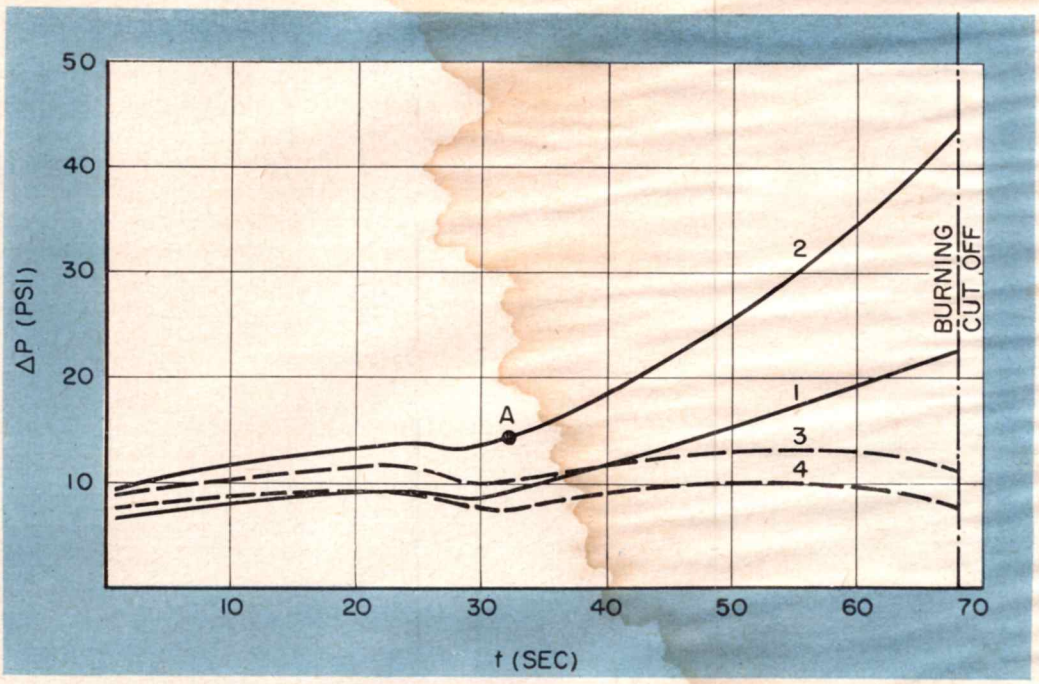


Figure 2—Effects of tank arrangements according to Figures 3 and 4 on injector pressure for German V-2 missile.

Curve 1 : oxidizer, original missile V-2.
Curve 2 : fuel, original missile V-2.
Curve 3 : oxidizer, when concentric tanks are used.
Curve 4 : fuel, when concentric tanks are used.

are further variables and constants, such as turbine and pump rpm, pump inlet and outlet pressures, pump efficiencies, and if occasion arises, the gas temperature at turbine exit as well as pressures at inlet and outlet of the turbine.

• • Adjustment Control of Powerplants

The method to be used for control depends on the application and purpose of the powerplant, and can be applied as (1) calibration by means of calibrating orifices, and (2) control by means of propellant tank arrangement.

The simplest way to adjust a powerplant for optimum operation is to use a calibrating orifice in the oxidizer or in the fuel line or in both, to obtain the desired propellant consumption. This type adjustment operates only at one optimum point (fixed values for all other dependent variables) and is sufficient for simple problems. Special methods are required when for example inertia, resulting from the missile acceleration, is acting on the hydraulic system. In this case, the pressure differential within the injection system is increasing by ΔP_{ox} and ΔP_f, respectively. This causes a different injection pressure $(P + \Delta P_{ox})$ and $(P + \Delta P_f)$, respectively, and hence a higher propellant consumption. Consequently, a variation in thrust occurs, and possibly an alteration of mixture ratio. Nevertheless, by suitable arrangement of the propellant tanks, it is possible to maintain the injection drop whereby an almost constant propellant consumption and mixture ratio is guaranteed.

If at first the missile drag, the thrust augmentation and the missile weight component are ignored, then the actual pressure differential ΔP is given

$$\Delta P = h\rho' C \tag{1}$$

when a constant propellant consumption during flight is assumed. Also,

$$C = \frac{F}{(M_o + M_p) - mt} \cdot \frac{1}{g} \tag{2}$$

From equations (1) and (2), for

$$h = (h_o - v_h t),$$

$$\Delta P = F\rho' \frac{(h_o - v_h t)}{[(M_o + M_p) - m t]\, g}$$

The oxidizer or fuel consumption is given by

$$m' = v_h A\rho'/g;$$

therefore, ΔP becomes

$$\Delta P = F \frac{h_o\rho' - (m' g/A)\, t}{(M - m t)\, g} \tag{3}$$

The numerator $y = [h_o\rho' - (m'g/A)t]$ represents the equation of a straight line. Its gradient depends on the change of the propellant level h, curve 1 in Figure 1. The expression $y = 1/(M - mt)g$ represents the equation of a hyperbola and shows the influence of the missile acceleration, curve 2 in Figure 2. The product of the two expressions gives the ΔP characteristics, curve 3 in Figure 1.

If the drag D, the thrust augmentation ΔF, as well as the missile component $(Mt \sin \varphi)$ are considered. then the designer has

$$\Delta P = [h_o\rho' - (m'g/A)t] \cdot \left[\frac{F + A_{ex}(P_{ex} - P_a) - D}{(M - m t)\, g} - \sin \phi\right] \tag{4}$$

To illustrate Equation 4, curves 1 and 2 in Figure 2 show the ΔP variation for the German missile V-2, Figure 3, when liquid oxygen and alcohol are used. The acceleration influence predominates because for large missiles only a slow decrease of h, consequent upon the large propellant surfaces, is to be expected.

An example of ΔP compensation for the V-2 missile by means of a concentric tank arrangement, Figure 4, is shown in curves 3 and 4 in Figure 2. These results are for comparison and do not consider the influence of the turbine pump unit. An undesirable ΔP tendency can be ameliorated if at the beginning of the steep acceleration curve (for example, point A in Figure 2) the propellant level has descended to the point where the influence of $y = [h_o\rho' - (m'g/A)t]$ predominates. By varying the value of h_o in connection

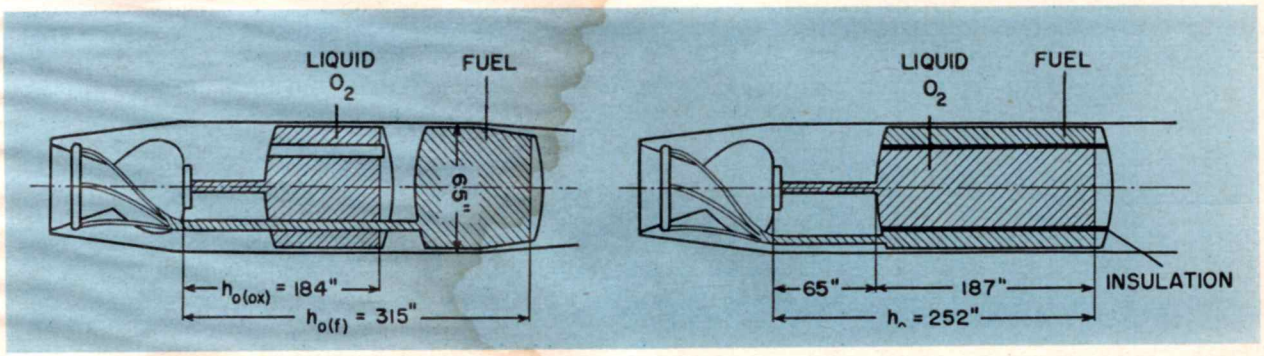


Figure 3 — Original "in line" tank arrangement of V-2 missile.

Figure 4 — Assumed concentric tank arrangement for the V-2 missile to offset acceleration influences on injector pressure.

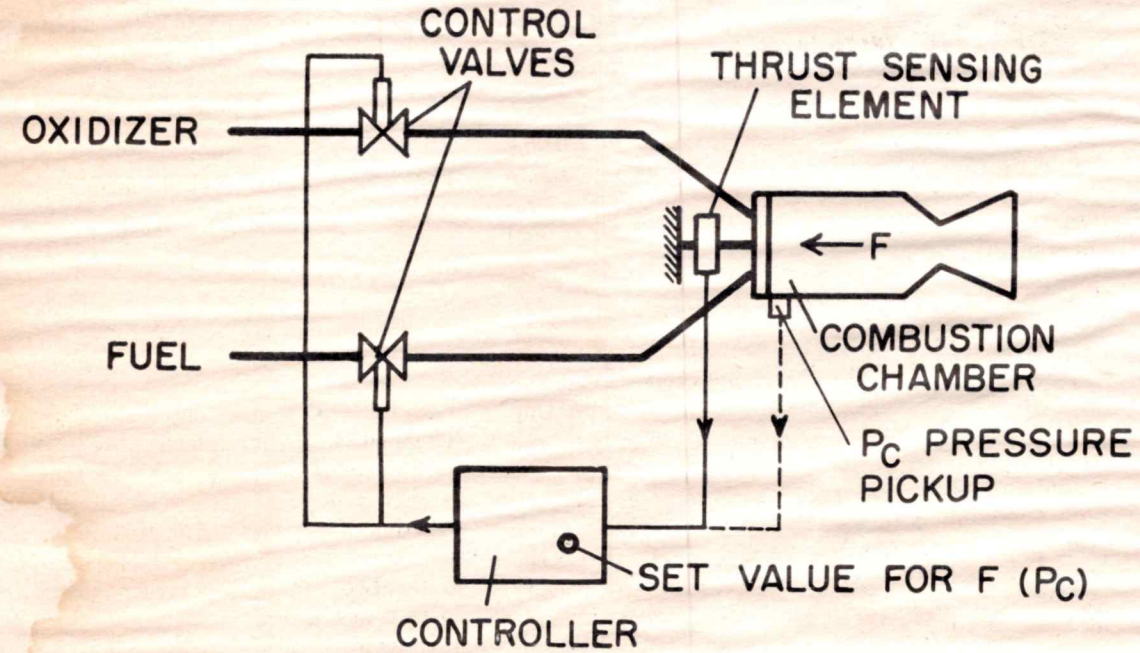


Figure 5—Automatic control of thrust by means of thrust measurement (or by combustion chamber pressure measurement) as the control variable.

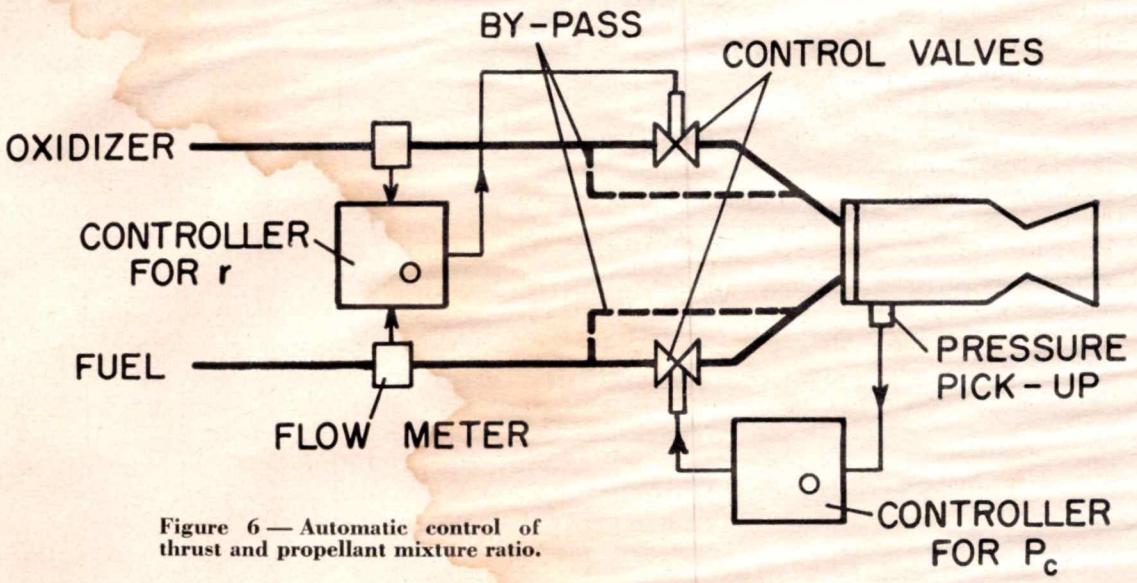


Figure 6 — Automatic control of thrust and propellant mixture ratio.

with the corresponding tank arrangement, it is always possible to find a satisfactory design.

• • Automatic Control of Powerplants

With the foregoing adjustment methods only one optimum operation condition can be realized, and disturbances can not be controlled. For greater flexibility a more elaborate means of control is required. The systems used are either mechanical, hydraulic, pneumatic or electrical, or a combination of these. The control procedure can be continuous or intermittent. Technical solutions are similar to automatic feedback devices.

For thrust control, F is measured directly and represents the control variable, Figure 5. The controller opens or closes both propellant valves, which must have the same characteristics in order not to vary the mixture ratio. When the thrust augmentation ΔF is of no disadvantage, the combustion chamber pressure P_c can also be used directly as the control variable (dashed line in Figure 5). The controller also actuates both propellant valves, which should have the same characteristics.

With a turbine pump unit, thrust control can be accomplished by controlling the rpm of turbine or pumps. The thrust augmentation ΔF can then be compensated by an auxiliary control variable. A major advantage of control through turbine rpm is that the oxidizer and fuel pumps vary their speed simultaneously thus preventing an appreciable variation of r.

Other control variables that can be used are the static pressure at the oxidizer or fuel pump inlet or outlet; and for special purposes the missile acceleration according to a predetermined program, for exam-

ple, constant acceleration. In this case, the control variable is given by the relation

$$C = \frac{F + A_{ex}(P_{ex} - P_a) - D}{(M - m\,t)\,g} - \sin\phi = \text{constant} \qquad (5)$$

To overcome starting difficulties, it may be suitable to use the turbine rpm or a propellant component pump

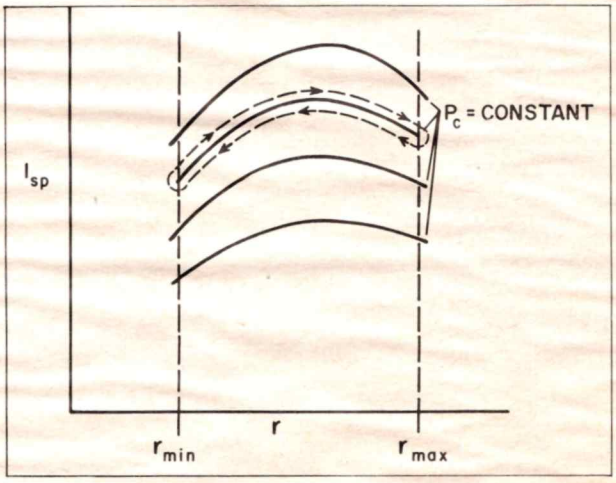


Figure 7—Range of test run in the I_{sp} versus r diagram.

pressure as the control variable during starting transient, and then to switch automatically to P_c as the main control variable.

● ● Mixture Ratio

Of special importance is control of the mixture ratio. In this way, the influence of propellant density variations, propellant flow rates, and rocket acceleration can be considered. An inaccuracy in the mixture ratio influences I_{sp}, the vehicle mass ratio, and the burning time thereby possibly causing considerable loss of performance (Reference 2). Correct control procedure can be achieved by measuring the oxidizer and fuel flow rates, and comparing them with the mixture ratio set value. When a deviation occurs, the mixture ratio controller will effect an adjustment until the deviation disappears.

If simultaneous thrust and mixture ratio control is required, a control system represented by a combination of loops for F and r is needed, Figure 6.

Because of the tendency for the combustion process to vary in an unstable manner, difficulties arise that lead to performance losses. Up to the present, this problem has been handled in an empirical manner. Nevertheless, there are theoretical papers (Reference 3) that discuss the probable reasons for the combustion instability and also propose control possibilities.

● ● Test Facilities

It is essential during the static firing test to check the parameters of the powerplant design, and to examine propellant combinations. Common methods of control by hand include some difficulties even for small engines. Besides the characteristic I_{sp} versus r curve, other studies are needed. In order to accomplish these, it is necessary to make wide use on the test stand of automatic control. Furthermore, by means of an additional arrangement of computers, other parameters can be determined.

At first the control of P_c = constant during the test run can be performed, (Reference 4). It is possible to determine the entire curve I_{sp} versus r for a small range of mixture ratio variations within a single run. This curve plots as a small loop, Figure 7. The test arrangement is shown in Figure 8. In this case, the oxidizer tank and the fuel tank are pressurized beyond the required maximum working pressure. After the burning process starts, valve 7 is governed by hand according to the manometer reading in such a way that the test run passes through the entire range from r_{max} *to* r_{min}, and back to r_{min}. (The fuel consumption follows by means of the automatic control of P_c = constant.) This method saves time and propellant expense, and improves test accuracy especially when oxidizers with a corrosive effect are used.

For the next step, not only P_c but also mixture ratio r is held constant. This arrangement is shown in Figure 9. Here the following problems are solved:

1) I_{sp} versus r, with P_c as the parameter.
2) I_{sp} versus P_c, with r as the parameter.
3) P_c = constant and r = constant.

This method corresponds to an acceptance test.

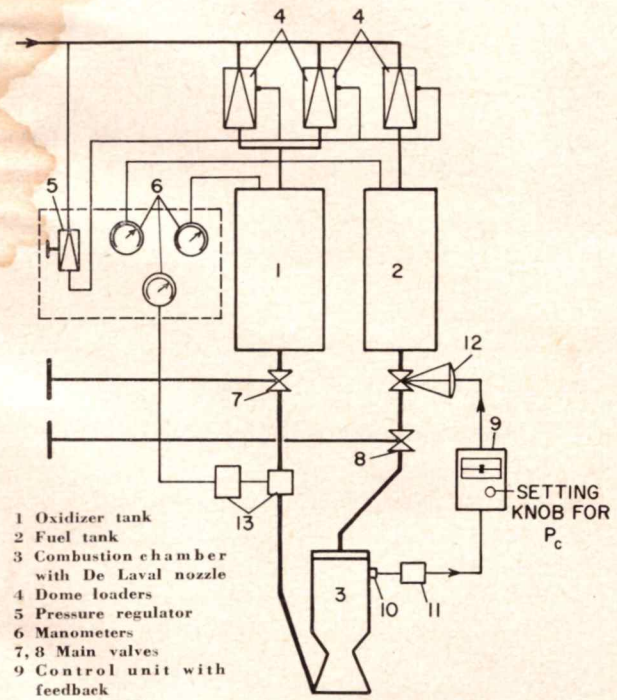


Figure 8—Experimental arrangement for control of propellant flow rate with P_c as the parameter.

The last step, with an automatically controlled test stand, is to evaluate the test values by means of computers, and to record the results even as the test run is being carried out. Besides the usual data such as tank pressures, thrust, propellant flow rate, combustion chamber pressure, other values can be determined by evaluation such as r, c, c^*, I_{sp} and V. For this, there results the computer arrangement shown by the dashed lines in Figure 9. The signals of the test instruments are fed to the computers which carry out the evaluations versus burning time t. END

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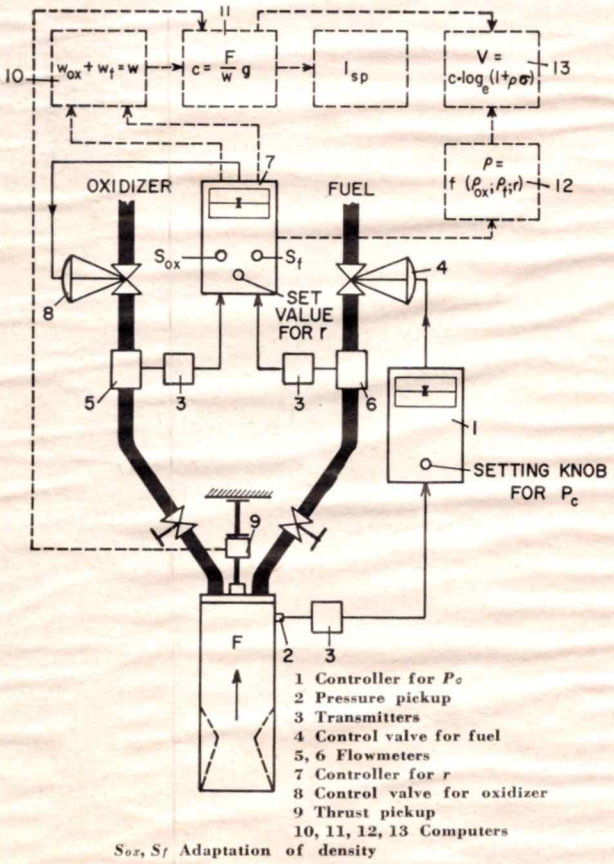
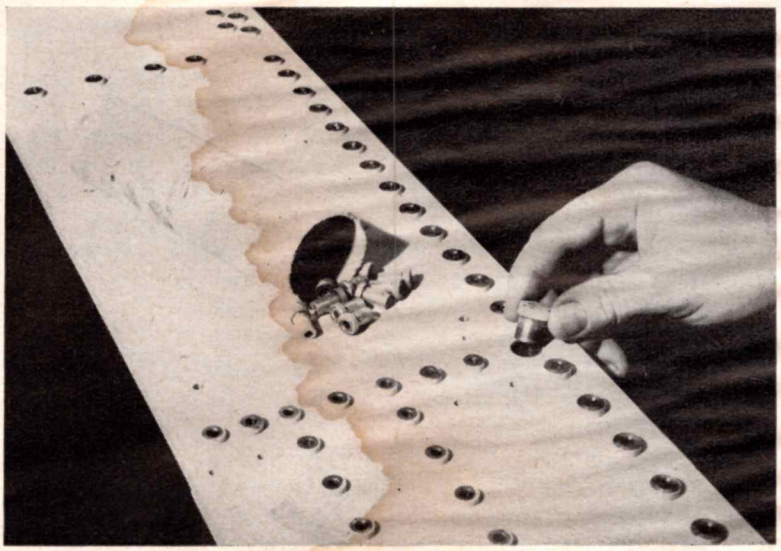


Figure 9—Experimental arrangement for automatic control with P_c and r as parameters, and additional evaluation of test data (dashed lines).

Deep-Freeze For Bushings

Martin Company of Baltimore uses frozen bushings to speed tool-making. Various size drill bushings are kept frozen for insertion in drill templates. Holes are drilled for a normal press-fit and the frozen bushings are inserted. Exposed to room temperature, they rapidly expand to a tight fit. Experience shows no distortion of the template.



MILTON W. ROSEN

DR. FRITZ ZWICKY

WILLIAM G. PURDY

ARTHUR P. ADAMSON

Roundtable Conference on THE VANGUARD

Artificial satellite may tell how fast gravity acts.

A SYMPOSIUM dealing with the utility and significance of artificial satellites was held in Washington, D. C. on October 31. Co-sponsored by the National Capital Section of the American Rocket Society and the Aviation Writers Association, the meeting comprised a question and answer session. Four engineers vitally connected with Project *Vanguard* made up the panel of experts: General Electric engineer Arthur P. Adamson, Martin engineer William G. Purdy, Naval Research Laboratory engineer Milton W. Rosen, and Cal Tech astrophysicist Fritz Zwicky.

The following questions and answers come from a transcription of the discussion, edited and condensed by AERO DIGEST.

• • Instrumentation and Utility

Q. How many satellites does Project *Vanguard* call for?

A. Ten units have been suggested but it is likely that enough *Vanguard* units will be manufactured to produce at least one successful satellite. Let us hope that there will be many of them: there are more ideas about what to do with them than can possibly be put into only one satellite.

Q. Does that mean that the instrumentation of the satellites will differ from unit to unit?

A. Yes. Great effort has been put into planning instrumentation, and it is also likely that slightly different telemetering systems will be used for the various units and for various purposes. This procedure was followed under the *Viking* high-altitude rocket research program: the instrumentation differed from one rocket to another. In many respects conventional telemetering equipment will be used; but since weight is at a pre-

mium, there will be a question of miniaturization to the fullest extent.

Q. What type power unit will be used to operate the instruments—solar energy or batteries?

A. Although solar energy may come into use and prove practical, it is likely that batteries will be used for the early satellites. A battery is reliable and its life is satisfactory for this purpose.

Q. What is the most important task of the satellite?

A. That question is difficult to answer because the different schools of science all claim that their specific studies are the most important. Of course, it is expected that we will obtain data on cosmic rays, the solar spectrum, solar energy, high altitude density, the Earth's magnetic fields and the aurora; but to mention any one of these or others as most important is extremely difficult.

It should also be pointed out that the satellites might be used to study the unique phenomenon of the speed of gravitational interaction; in 200 years science has not been able to measure it accurately. By indirect methods the speed of gravitational interaction has been measured only within 50 percent. This has been determined from studies and measurements of the largest constellations in the universe. The values obtained ranged from 200,000 to 400,000 kilometers per second (speed of light is 300,000 kilometers per second). If the speed were infinite, we should observe clusters of galaxies bigger and bigger. But they have a size limit because the speed of interaction has a limit. If gravitational interaction speed were equal to

SATELLITE

the speed of light, the biggest clusters of galaxies would be 20-million light years in diameter. But constellations with diameters up to 50- and 60-million light years in diameter have been observed. The satellites may well help us measure these diameters accurately.

Other important phenomena include observation of the impact of meteorites on the satellites. At 50 or 60 miles per second a grain of cosmic dust striking the satellite would produce a jet of light. This could easily be observed from the pinpoint of contact. These observations might well be significant for the construction of our future manned satellites.

Q. Is the round basketball shape indicative of the instrumentation?

A. The advantages of the spherical shape are several: the satellite will always present the same aspects in

Members of the Panel

Fritz Zwicky is Professor of Astrophysics at the California Institute of Technology and has been Chief Research Consultant of Aerojet-General Corporation. Zwicky, born in Bulgaria in 1898, was granted a Ph.D. by Switzerland's Federal Institute of Technology in 1922. In 1925 he went to the California Institute of Technology on a Rockefeller International Education Board fellowship. Since 1947, Zwicky has served as astronomer at the Mount Wilson and Palomar Mountain observatories. His discoveries of supernovae are said to be among the more important astronomical contributions of this century. From 1943 to 1949, Zwicky was Aerojet's director of research. His services to the government were recognized in 1949 when he was awarded the Presidential Medal of Freedom.

Milton W. Rosen is Technical Director for project *Vanguard*. Born in Philadelphia, Pennsylvania on July 25, 1915, he was educated in Philadelphia and was graduated from the University of Pennsylvania. He also studied at the University of Pittsburgh and the California Institute of Technology. Since 1940, Rosen has been a member of the Naval Research Laboratory's scientific staff. In 1945, he proposed this idea and helped organize a group to explore the upper atmosphere with rockets. The *Viking* rocket was developed under his direction.

Arthur P. Adamson was graduated from the University of Southern California in 1941 with a B.S.M.E. degree. He then joined the General Electric Company as factory contact engineer and design engineer on small electric motors. In 1947, Adamson was named Supervisor, Missile Autopilot Development; and in 1951, he was appointed Assistant Project Engineer in the Guided Missiles Department. While here, he participated in the V-2, *Bumper* and *Hermes* programs in engineering and management capacities. In January 1955, Adamson was appointed Manager, Rocket and Ramjet Section, which has the responsibility for developing General Electric's rocket engine for the first stage rocket of Project *Vanguard*.

William G. Purdy was born in Harris, Missouri in 1917. With a B.S.C.E. degree from the University of Missouri, he joined the Martin Company of Baltimore in 1941. Purdy was assigned to duties in the field of vibrations and flight test instruments. In 1947, when the Martin Company was awarded a Navy contract to build and flight test the *Viking* rockets, Purdy was appointed project engineer, a title he still holds. Under his direction, Martin has built 14 *Viking* rockets.

directional flight. This is important in the measurement of density of the sparse molecules in space, which determines the lifetime of the satellite. But as far as the instrumentation is concerned, the shape is not important; if there were good reasons for using some other shape this could be tried.

Q. Will visual observation of the satellites be of value for the experiments?

A. Certainly. It is quite possible that without using binoculars we will be able to observe the satellites at dusk and dawn, if we know where to look for them. If a satellite comes within 1500 miles of Mount Palomar we will be able to follow it through our telescopes for some time. Deviations in its orbital velocity will of course indicate differences in molecular densities. Any interaction is likely to dampen the orbit out; as a matter of fact, all matter in space is subject to tidal action. We are not certain whether drag effects or electromagnetic effects drown out tidal effects. The satellite's orbit will help us provide answers.

Q. Do you anticipate any difficulties in telemetering the various data back to Earth?

A. It is not considered a problem. Using very high frequencies we have communicated with high-altitude research rockets on numerous occasions and have not had any difficulties. Remember that radar signals have been made to bounce off the Moon, going twice through the ionosphere, once out and once back. This is really no problem.

• • Orbits

Q. How long will the satellites remain in their orbits?

A. We don't know. Under the assumption that the early satellites will orbit in ellipses with the apogee and perigee at approximately 800 and 250 miles from the Earth's surface, respectively, the satellites may have a lifetime of perhaps four weeks, perhaps not even that long, perhaps longer.

Q. Are elliptical orbits preferred to circular ones?

A. Not necessarily; it depends on what we want to study. But to achieve a circular orbit is considered almost impossible; it would be one chance in a million, so it is practically certain that the *Vanguard* orbits will be elliptical.

Q. Can the exact orbit be determined?

A. No, not until we have gathered some experience will it be possible to predict the orbits with any accuracy. It is conceivable that the satellites may pass over Washington, D. C., although this should not be construed to mean that such orbits have been decided on. For the United States, the best orbital inclination would be from 30 degrees north to 50 degrees north.

A more inclined orbit would give more people a chance to see the satellite. If the orbit went over the poles, everyone would see it but at much greater intervals between observations.

Q. Will the satellites be illuminated to make observations easier?

A. There are different ways a satellite could be illuminated; but information about these methods or their employment has not been released. Theoretically, it will be possible to paint the satellites with a phosphorescent substance that will be excited by the sun's ultraviolet rays. The satellite might also be illuminated from the inside; and lastly, it might be possible to illuminate the vehicle by using searchlights located on Earth.

• • Data Available to Science

Q. It is understood that the data obtained from the satellites will be made available to all countries participating in the International Geophysical Year. Why is it then that Project *Vanguard* is wrapped in so much security?

A. The scheme in military developments is to keep information secure from a potential enemy. For the success of the *Vanguard* project we must use the engineering and scientific skills acquired in the course of military developments. Because such skills are used on a scientific project does not make them available for declassification.

Q. Is it likely that the Soviet will launch their satellites before we do?

A. Most people overestimate democracy and underestimate the Soviet system. Their scientists are known to be quite capable: when a man comes to you and says to start thinking, and you know that you can save your life and your family from concentration camp, you think. These people certainly have an excellent chance to overtake us. We have experienced this before (the atomic bomb) and we may experience it again. The many jealousies, bureaucracies and the nonsense of passing the buck, from which a democracy often suffers, must be taken into consideration. We may not be in such a good position as most people believe.

Q. Is it possible that our satellites may go astray and that they might fall in the Soviet? What would be the consequences of such incidents?

A. One can never rule out the possibility of unsuccessful launchings. If a small basketball-size satellite —or fragment of it—would crash in the Soviet, or anywhere else, the physical damage to the country involved would probably not be noticeable. Some political disturbance might follow, although one must remember that the Soviet cannot rule out the very same possibilities.

Q. Will we succeed in producing the *Vanguard* satellites in time for the International Geophysical Year?

A. They will be launched as originally planned—during the International Geophysical Year, between July 1, 1957 and December 31, 1958. END

The strength-weight concept based on tensile strength analysis is extended to include compression. By inserting material cost in the formula, the engineer can find the most economical metal.

STRENGTH-WEIGHT RATIO

Under Different Loadings

MARX MOLLER
Acting Chief of Reactor Engineering
Martin Company, Baltimore

THE AIRCRAFT INDUSTRY is particularly aware of the value of the strength-weight ratio as a suitability index for selecting the best material for a specific structural job.

Yet, as with many simple values, the typical strength-weight ratio—the comparison using tensile strength and unit weight—is useful only as an index. It does not give enough information to picture fully the structural applications in which one material is superior to another. It seems desirable to develop a means for clearly defining the field of usefulness of a structural material, and to extend this means to the cost field, so that it may be applied where cost as well as weight is an important factor.

The strength-weight index is derived most easily when the structure is to carry a tensile load. An index for each material is found simply by dividing its applicable allowable stress in tension—whether ultimate, yield or working stress—by its unit weight. The index is not dimensionless, and its unit of measurement—stress psi divided by pounds per cubic inch of weight cancels out to inches—is rather interesting, since apparently it is not applicable to the value being formulated. Canceling only the inch units produces a unit of inch pounds per pound, which conveys the measurement idea much better. Materials evaluated by this method can be compared by value, or plotted on a simple bar chart for graphic presentation, as in Figure 1. The field of comparison may be widened by introducing another variable such as service temperature. Figure 2. This graph shows the advantages of specific materials over a considerable temperature range.

An Index for Compression

Unfortunately, loading in tension alone is not generally met in structural applications, and the use of the strength-weight index to indicate suitability of a material under more complex loadings is not apparent. In compression, for example, the load that a member can carry is determined by its strength and stiffness, and also by its cross-sectional area and shape, its length,

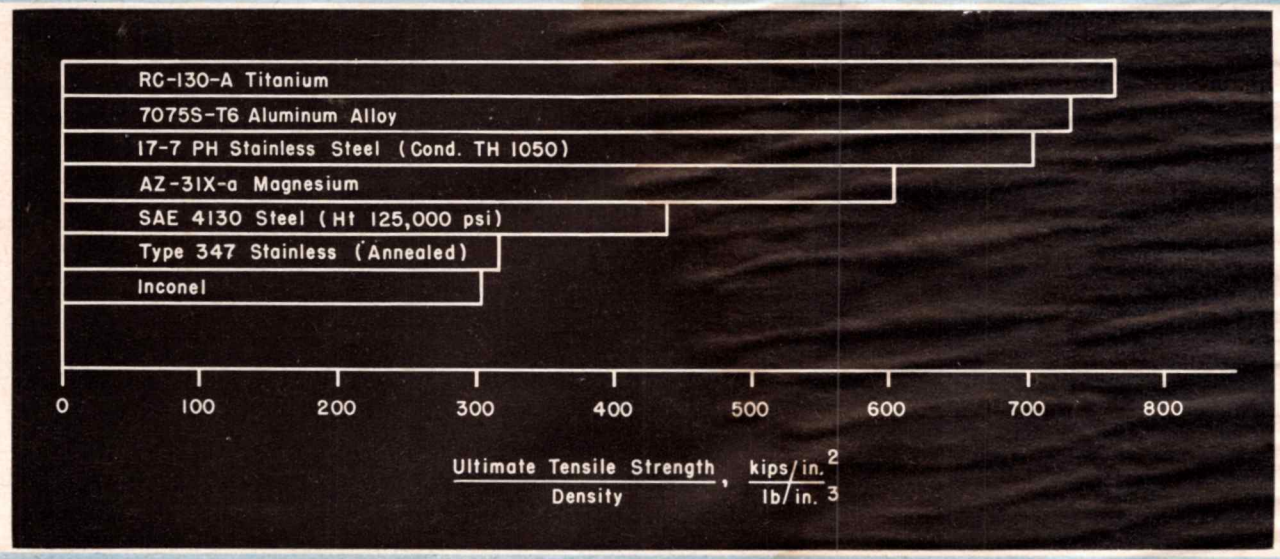


Figure 1—Tensile-strength/weight index at room temperature.

and its support. The problem, then, is to choose a sample shape typical of compression design—a shape that is susceptible to mathematical analysis and is still able to give a true picture of compression-loaded structures—and apply to it a formula in which the length and support terms are general enough to satisfy most practical conditions. Standard column formulas are not practical for a strength-weight analysis because the factors involved—the modulus of elasticity, the column length, the radius of gyration and the end connections—are not sensitive weight indicators. The discontinuities of the mathematical formulation as the column varies from a compression block to a short column, and then to the classical Euler long column, make the choice of a typical length and shape more difficult.

Satisfactory formulas can be found, though, in thin plate analysis methods. A typical example is the formula for finding the buckling load on a narrow plate of semi-infinite length, loaded in axial compression at the ends and simply supported along the unloaded edges. Here the length of the plate—provided it is several times the width—is not a factor in the critical load. The formula

$$N_{crit} = \frac{k\pi^2 E h^3}{12\,(1-\mu^2)\,b^2},$$

where N_{crit} is the running axial load that the plate can support without buckling, k is an arbitrary constant, E is the modulus of elasticity, h is the plate thickness and b the span between the edge supports, is suitable for the purpose of strength-weight study; k and π are constants; and for materials in general use, Poisson's ratio μ can be taken as constant at 0.33 without introducing serious errors. The essential considerations then are: (1) the modulus of elasticity, (2) plate thickness, and (3) span (distance between supports). The first is a property of the material being considered; the second is directly related to the weight; and the third can be made a constant, within reasonable limits. Thus the formula relates strength in compression (buckling load) to material properties and weight.

• • Effect of Block Compression

This formula is still not completely satisfactory since, as a result of increasing h (the weight term) without limit, N_{crit} increases even more rapidly. A validity check at large values of h shows that the stress (N_{crit}/h) may be many times greater than the allowable ultimate stress of the material. Obviously there is a point beyond which this plate formula does not apply. It is accurate enough to define this point as the value where the yield stress (σ_y) equals the buckling stress; or in terms of running load, where

$$(\sigma_y)\,h = N_{crit}.$$

Below this point, the maximum load a plate can carry is the critical buckling load, determined by plate stiffness and thickness. Above this point the maximum

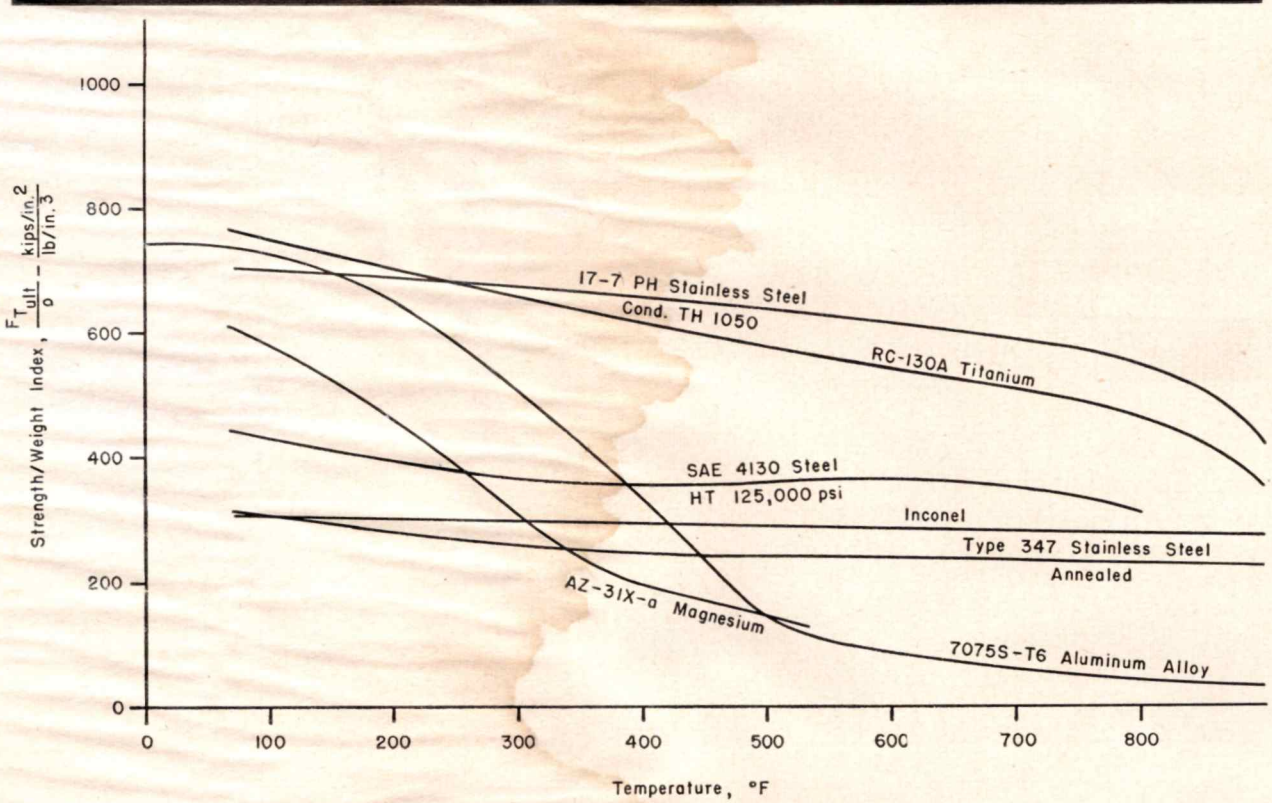


Figure 2—Tensile-strength/weight index versus temperature.

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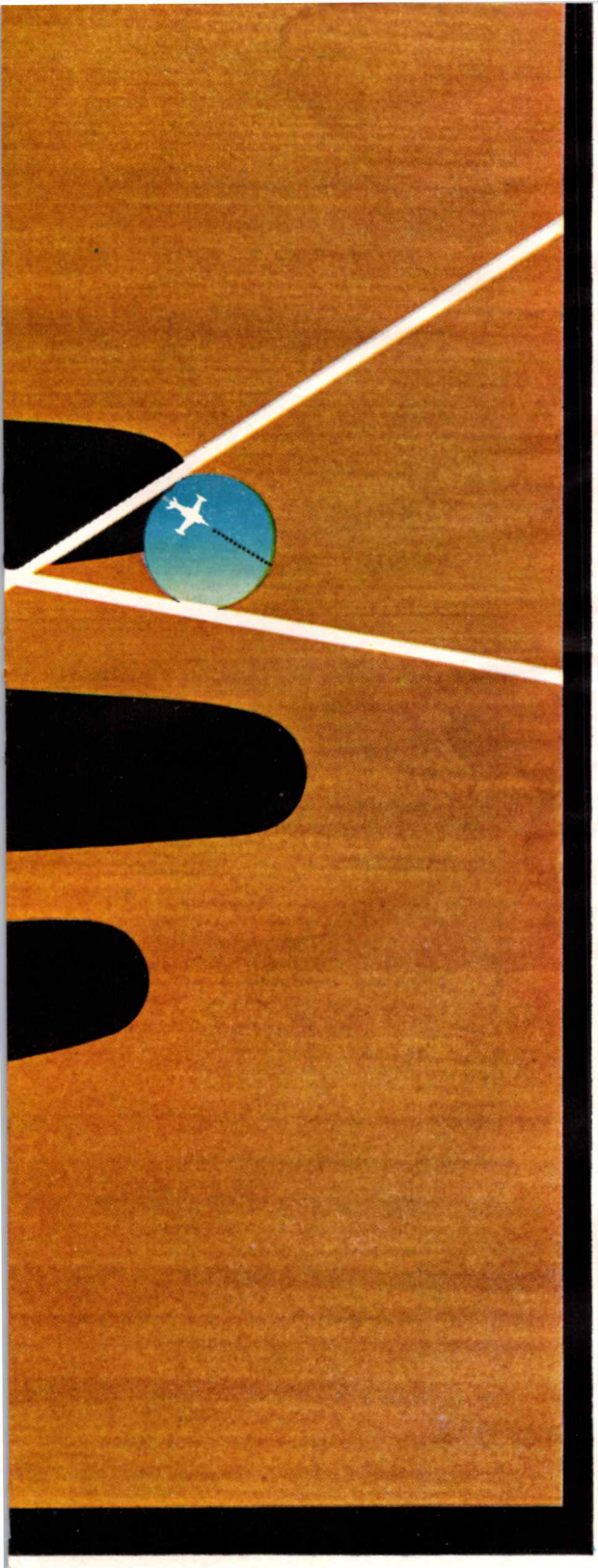

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Strength-Weight

load is taken to be the load at which the plate reaches yield stress, and is determined by plate strength and thickness.

To present these data in strength-weight terms, it is necessary to substitute a weight expression for the thickness, h. Let w = the weight of a unit area of the plate, and ρ = density or unit weight of the plate material. Now $w = \rho h$, and h may be expressed as w/ρ. Then

$$N_{crit} = \frac{k\pi^2 E w^3}{12\,(1-\mu^2)\,b^2\rho^3}.$$

Plotting N_{crit} against w shows how much load a given plate weight can sustain. For the region above the point of discontinuity—where the plate is acting as a compression block—a formula may be written as follows:

$$N_{allow} = (\sigma_y)\,h = (\sigma_y)\,(w/\rho).$$

This analysis can be applied to show the axial compression loads that various materials in a given width plate, simply supported along the unloaded edges, can carry. Figure 3 shows these data for plates 6 inches

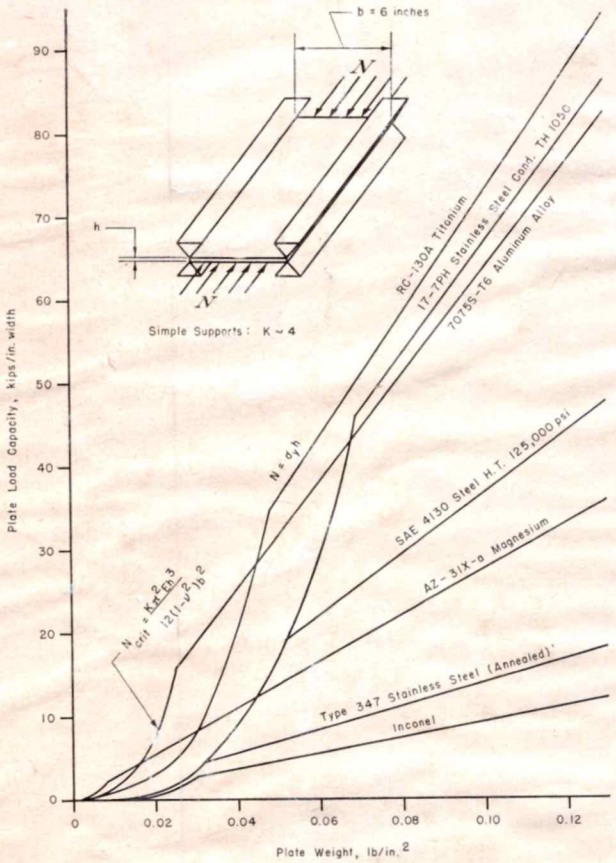

Figure 3 (above)—Compression allowable load versus weight at room temperature.

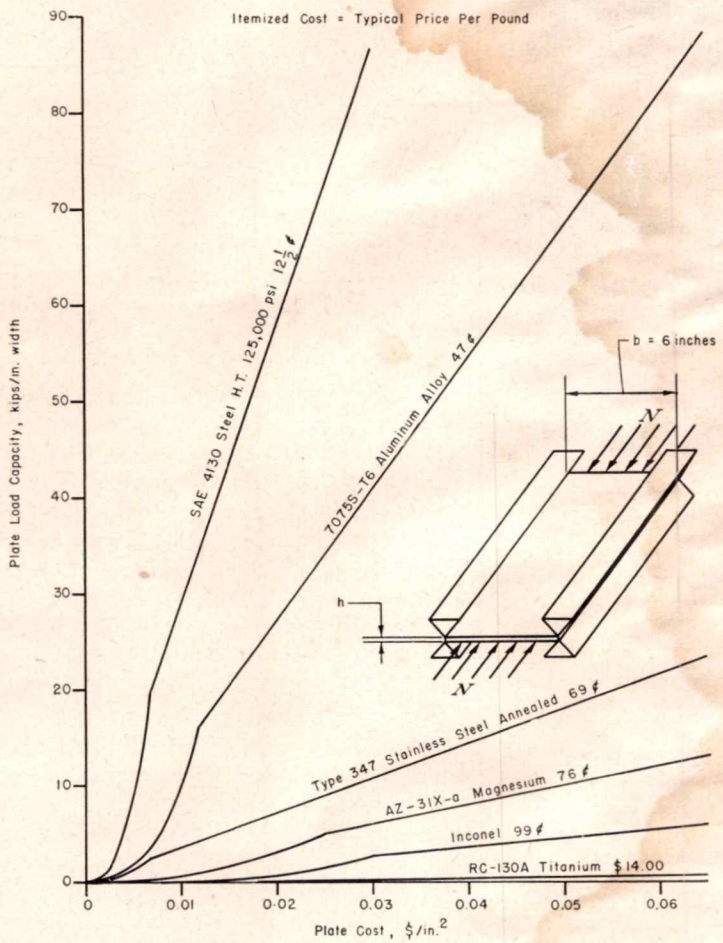

Figure 4—Compression allowable load versus cost at room temperature.

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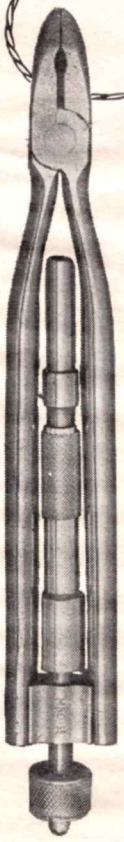

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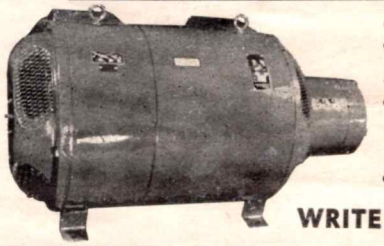

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Strength-Weight

wide between supports. Below the point of discontinuity the load that a given plate weight can support is inversely proportional to the third power of the density of the plate material, and directly proportional to the material's modulus of elasticity. Above the point of discontinuity, for a fixed w the load is inversely proportional to the first power of the density, and directly proportional to the strength of the material. It is seen that the properties of the materials chosen are such that for light loads the materials of lower density are superior, while for higher loads the stronger and heavier materials tend to be better.

• • Shear Analysis

This compression analysis is not as flexible as on the tension study, but it is useful because structures designed by compression or stability occur much more frequently than those designed by tension loads.

Structures loaded in shear present a problem similar to the compression problem. Here the load that can be carried by a shear panel is determined by: (1) the modulus of rigidity, (2) panel size and shape, (3) panel supports and restraints, and (4) strength of the material.

Again there is a point of discontinuity—a panel thickness below which the panels buckle in tension field action, above which they act as stable webs and do not buckle. There is a mathematical correspondence in the fact that the modulus of rigidity is proportional to the modulus of elasticity, and the shear strength is proportional to the tensile strength. A rigid mathematical proof perhaps may not be possible except in limited cases; but the problem seems enough like the compression problem that the compression chart should be useful in selecting materials to be loaded in shear.

In the economic field, the price of the materials can be inserted by multiplying the weight ordinate by the cost per pound; in this way, a load-capacity versus material-cost curve can be plotted. Figure 4 is an example of this approach; typical mill prices are used to find the cost of the materials shown in Figure 3. Thus Figure 4 is an index of how much it costs to carry a load in compression. To use these values for estimating or study purposes would require that some evaluation of the cost of handling the various materials be included in the prices used in plotting the curves.

The strength-weight concept, although it cannot answer all questions, is a useful tool for the designer. In its simplest form, he may use it to compare the tensile load capacities of various materials; in the economic field he can insert the price, making it possible to plot a load-capacity versus material-cost curve; and, with a practical compression analysis, he can extend the area in which he can logically apply the strength-weight concept to select the best material for a job. END

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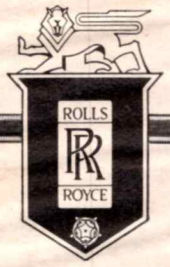
POWERED BY  ROLLS-ROYCE

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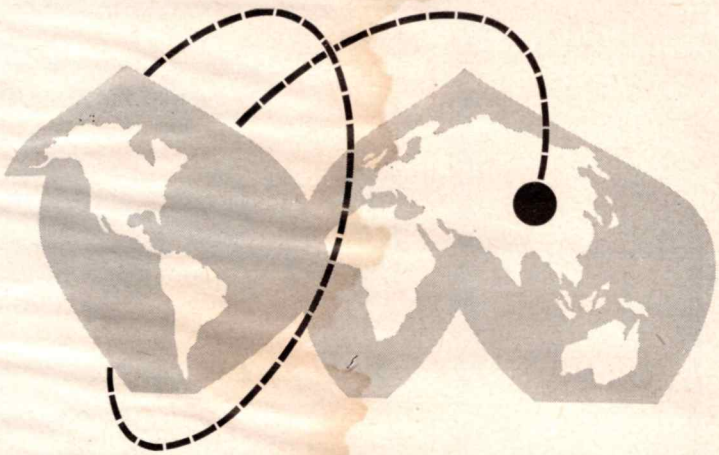
The problem of ground-to-satellite communications depends on characteristics of satellites, their orbits, radio frequencies used and noise conditions.



THE SATELLITE VEHICLE

For Communications and Navigation

HOWARD E. CANNEY, JR., President
and **FREDERICK I. ORDWAY, III** Vice-President
Astronautics Associates
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STUDIES have already been undertaken for two cases involving use of a satellite as a communications agency: first as a transponder or repeater for terrestrial communications; and second, as a means for practical communications across space.

Frequencies high enough to pierce the electrified layers of the ionosphere will be required. Generally, frequencies above 50 megacycles per second pierce the ionosphere and pass into space, although the intensity of sunspots alter this figure. Out in space, signal-to-noise ratios will be improved over those possible on Earth. Minimum requirements indicate a ratio of about 100 to 1 for Earth to Moon transmission. If the transmitting and receiving antennas are in space, special conditions exist. Fading, in the terrestrial sense, will undoubtedly be reduced; but in space communications, conditions in the upper atmosphere may often seriously affect the signal strength, in turn affecting reception of an outgoing beam to the Moon. It will be seen that simple penetration of the ionosphere is hardly the whole story. Space, while offering better communications conditions, is not free from noise. Thermal noise, galaxy noise and solar noise exist and vary in intensity.

• • Orbital Radio Relay

On the surface of Earth, transmission distances are affected by the frequency of radio signals, topography, electrical condition of the soil, the season, time of day, weather and sunspots. The atmosphere, or more accurately, the Heaviside layer, is opaque to signals up to about 30 megacycles, though special calculations, taking into account the rapid fluctuations of the various layers of the ionosphere, must be used to determine accurately the maximum usable frequency. It is apparent, then, that several things may happen; waves may be reflected, absorbed, allowed to penetrate, or some combination of these. Very short waves and microwaves which on the surface of the Earth tend to be somewhat line-of-sight, lend themselves to convenient focusing and hence beaming at satellite vehicles for re-transmission to the point of destination.

Arthur C. Clarke suggested this use for satellite vehicle ten years ago, Reference 1. His proposal featured three spherical relay stations (transponders) 120 degrees apart in a 24-hour (22,300 mile) orbit. These were designed to provide continuous worldwide radio and television coverage, as well as navigation and safety services. Since the vehicles were to be interconnected by microwave link, one may assume that the entire system was originally conceived as a system of active repeaters. The vehicles could thus exchange signals with each other as well as with points on the ground. Being stationary in space with respect to the Earth, Clarke suggested that the transmitting and receiving antennas, once aimed at the vehicles, could be locked.

It is believed that satellite radio and television communication will enjoy a great improvement in signal to noise ratio, in large part a result of the shorter transit distances of signals through the atmosphere. By communication depending upon the vehicles instead of the ionosphere, the influence of fade, skip and magnetic storms will be greatly reduced.

It has been speculated that satellites may replace most networks of cables and conventional television channels, and some applications of radio. Over and above the general problem of getting a satellite into

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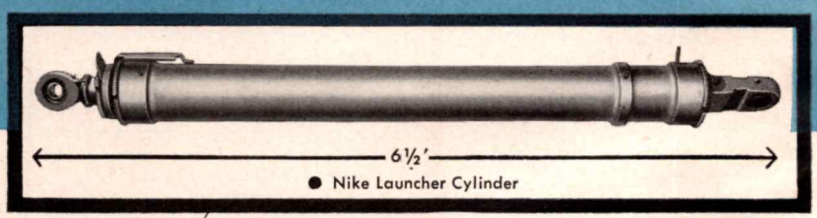

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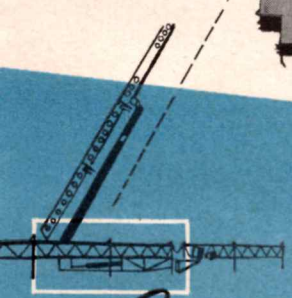

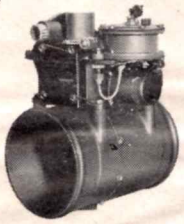

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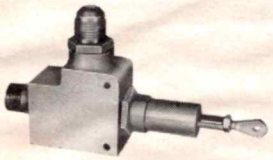

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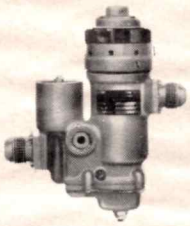

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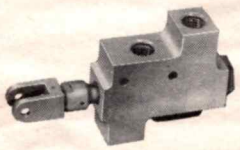

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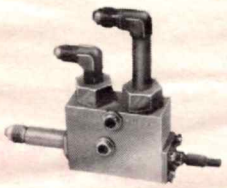

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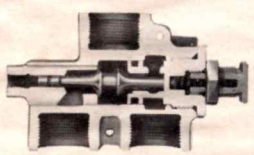

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orbit there are some immediate and practical considerations bearing on terrestrial communications, objectives that affect the selection of the orbits themselves. This matter has been studied by Dr. John R. Pierce. A summary of his views may be found in a proposal submitted to the National Science Foundation by the American Rocket Society, and in subsequent papers, References 2, 3 and 4. It is useful to dwell at some length on the substance of Pierce's study for its balanced approach to the problem.

• • Transocean Communications

He mentions that a 36-channel two-way transatlantic submarine cable is being laid between the United States and England for a reported price of $35-million. A channel 30 times this wide, needed for television transmission, would cost in the neighborhood of $1-billion and is scarcely worth it. A combination of land and submarine connections by way of Greenland and Iceland might help somewhat but the prevailing climate along the route would tend to discourage that solution. A similar route to Asia by way of the Bering Strait has these and other disadvantages.

He reviews a proposal that featured a continuous chain of airplanes flying the Atlantic and understandably finds this unattractive, though technically feasible. (A similar idea had previously been suggested in the United States for long-distance overland television transmission. The germ of the satellite transponder idea is detectable). In introducing the idea of the satellite, Pierce makes the point of stressing its inferiority to overland networks such as the $40-million TD2, built by the American Telephone and Telegraph Company, because of its inability to drop and add hook-ups along the routes it covers. Over the seas, though, he feels that the satellite could be competitive. A condensed summary of four possible approaches (there may be others) for a 5-megacycle video channel provided by an 8-digit binary pulse code modulation system using a 10-centimeter (3000 megacycle) wavelength and Earth antennas 250 feet in diameter, is shown in Table 1.

Cases A and B use metal spheres that scatter signals isotropically, so that one only needs to point the beamed transmitter at them. Power requirements for ground equipment in Case A seem excessive, and the 1000 foot spheres necessary at that altitude are not easy to place. Case B reduces all elements by a factor of 10 except the number of spheres, which is increased. In fairly rapid motion, one or more spheres would always be visible to the transmitter, and the ground power requirement of 100 kilowatts would not be too serious.

Case C drastically reduces the power required but introduces some serious problems of positioning and orientation. Solar and lunar perturbations would require radio control of movable weights attached to the mirror, though satellite power requirements would be small. Perturbations of the orbit would probably be large enough to demand steerable antennas on the ground. Furthermore, a planar mirror reflects signals to only one destination. In general, the great advantage of passive repeaters (cases A, B and C) is the large number of two-way channels possible at various wavelengths. Modifications and improvements could be made to the ground equipment without the need to modify the satellite. The great disadvantage is the large power requirements for passive repeaters, especially with the spheres.

Case D, an active repeater, requires power, but only

TABLE 1 FEATURES OF THE COMMUNICATIONS SATELLITE

Case	Type Repeater; Altitude	Power Output (watts)		Orientation Required km/degrees	Advantages	Disadvantages
		Earth transmitter	Repeater transmitter			
A	304.8 m (1000 ft) sphere at 35,903 km	10^6	0	0	No orientation problem. Practically no motion.	Expensive because of size and altitude.
B	30.48 m (100 ft) sphere at 3542 km	10^5	0	0	Less power than A. May be cheaper. No orientation problem.	More vehicles required (10). May produce multiple images.
C	30.48 m circular planar mirror at 35,903 km	5.10^4	0	$\pm 29/\pm 0.047$	Less power than A or B. Higher reflectance.	Serious positioning and orientation problems. Needs power for servos. One destination.
D	3.048 m antennas; vehicle at 35,903 km	10^2	0.03	$\pm 580/\pm 0.95$	Very small power needed in ground equipment. Less orientation problem. Small antennas and vehicle size.	Power drain in satellite. Limitation in number of channels and in amount of modification possible to ground equipment.

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For further information circle Reader Reply No. 28

a small amount. A wide beam, coupled with a beam shift only half that for a mirror, reduces but does not remove the orientation problem. Unfortunately, the power supply required by an active repeater has a finite life (though solar batteries or generators may alleviate the problem). More serious is the limited channel capacity. Adjustments to the ground equipment and changes in the nature of the signal may improve the information content of messages, but with a predesigned transponder this is not likely to help much. Of the four possibilities presented by Dr. Pierce, Case B is the most attractive. It is susceptible to early attainment, and can also be used immediately for navigation and geodetic triangulation. The only forbidding aspect is the large number of satellites specified.

One stationary orbit exists around the Earth at 22,300 miles. Another, mentioned by Clarke, Reference 5, is a circumterrestrial orbit 40,000 miles beyond the Moon. "A body here would always be invisible from the Earth, being permanently eclipsed by the Moon. As it would appear fixed over the very center of the satellite's hidden hemisphere, it would be an ideal site for a radio transmitter when the far side of the Moon is colonized." How this arrangement contacts the Earth is not clear unless this is supplemented by repeaters placed at the Moon's trojan points. He may have had this in mind because he suggests elsewhere, an artificial planet traveling in the Earth's orbit, to enable us to "see around the Sun." The only place that could rely on the repeater remaining at a fixed distance is at one of the trojan points; otherwise the repeater would slowly drift away from the Earth.

● ● Frequency Relations

Wernher von Braun in Reference 6 considers the problem of communications with Mars in terms of a situation where one end of the link is on the surface of the Earth. By way of illustrating useful parameters, he explores two cases, one at 600 megacycles with 60,000 watts of power and another at 3000 megacycles with the same power. The space ship transmitter weighs three metric tons.

The first case, 600 megacycles, uses an antenna area of 10^6 square centimeters, which signal would reach Pluto with doubtful readability. This would allow an excess of 36 decibels even at the maximum distance between the Earth and Mars. This reserve permits a theoretical reduction in transmitter power and antenna size and results in an increase in bandwidth, allowing transmission of speech and music. The second case, 3000 megacycles, uses an antenna area of 7.5×10^4 square centimeters, which would permit radiotelephony up to 30,000,000 miles and radio telegraphy at any time.

Transmission between a receding space ship and an orbiting station, could, under certain conditions, have considerable Doppler effect, the maximum possible being 298 kilocycles per second. Purely from the standpoint of signal-to-noise ratio, the frequency range between 100 and 200 megacycles appears to be most favorable. Below 100 megacycles cosmic noise increases and above 200 megacycles receiver noises increase. Received signal power is proportional to bandwidth, but so is noise power in the receiver. Consequently, a net power boost by means of signal pulsing is of small value, and one would seek to narrow the bandwidths rather than to broaden them, Reference 6. But this is not desirable.

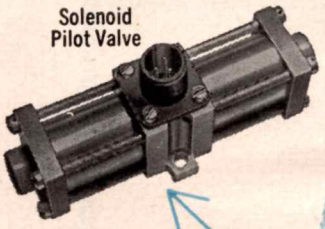
Another aspect of frequency, mentioned by Reference 7, indicates that spectrographic effects set in between 10,000 and 30,000 megacycles. In this range one finds atmospheric absorption lines for water vapor and oxygen. Considering all these data, one may suppose from an inspection of Table 34 in Reference 6 that a compromise frequency of about 1500 megacycles would work out about as well as any, though von Braun recommends 300 megacycles with a power of only 1000 watts to capitalize on the frequency characteristics of the Resnatron tube and the inherently wider bandwidth permitted. This does not contradict the statements about the 100-200 megacycle band, since they were made purely from the standpoint of signal-to-noise ratio. Compared with the theoretical reach of the 600 megacycle transmitter, on the basis of frequency, this may seem somewhat marginal. But if the designed is limited to three metric tons of weight, he considers first how far he must reach, he settles for the minimum power that will accomplish this, and then juggles the rest of his parameters in a way to convert what he has gained into bandwidth in the transmitted signal.

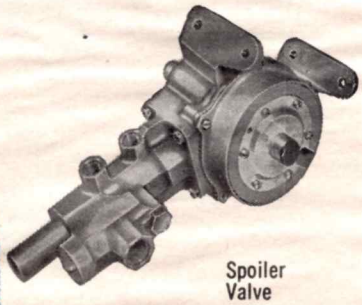
● ● Ground to Space Communications

A preliminary study of such factors as those discussed does suggest that for the solar system one is not likely to have too much difficulty setting up suitable communications network between the ground stations and the satellites and traveling space ships, once the performance of the vehicles and the ships have been worked out. Ground stations on the Moon and planets will permit the erection of larger installations than those conveniently possible in space; and these, probably with transponding assistance of smaller units in space, show promise of fulfilling most of communications requirements. The only novel problem associated with space communications, or between the Earth or Earth satellite and a space ship over interplanetary distances, is the matter of signal transit, which occurs at the rate of eight minutes per astronomical unit.

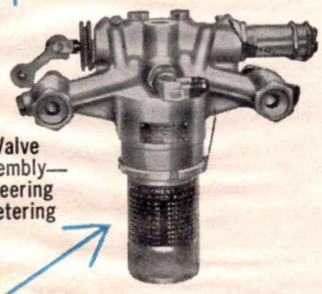
This problem may conceivably be serious in emergencies which often depend for their solution on rapid exchange of information. Signal transit to Mars at its closest approach would be about three minutes each way or six minutes to get the answer to a question. For faster exchange, perhaps some procedure could be worked out with substitutes for the conventional comment-and-respose technique, a procedure such as

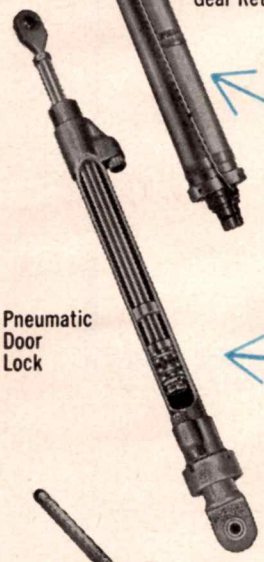
TONS OF POWER

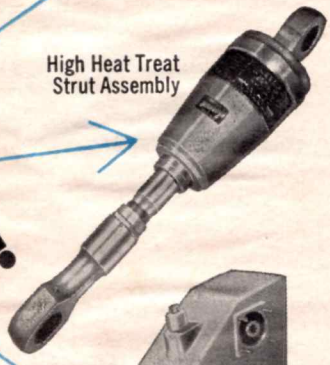

Solenoid Pilot Valve


Spoiler Valve

Strut Assembly—Main Landing Gear Retract


Valve Assembly—Steering Metering


Pneumatic Door Lock


High Heat Treat Strut Assembly

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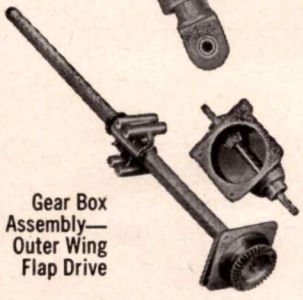
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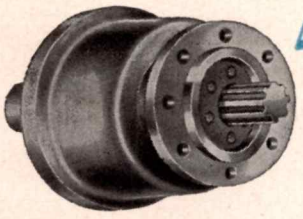
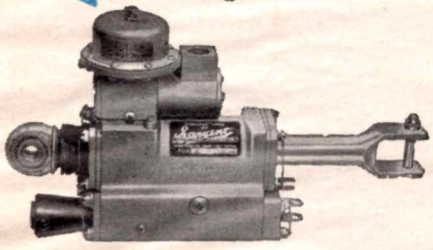

Hydraulic Motor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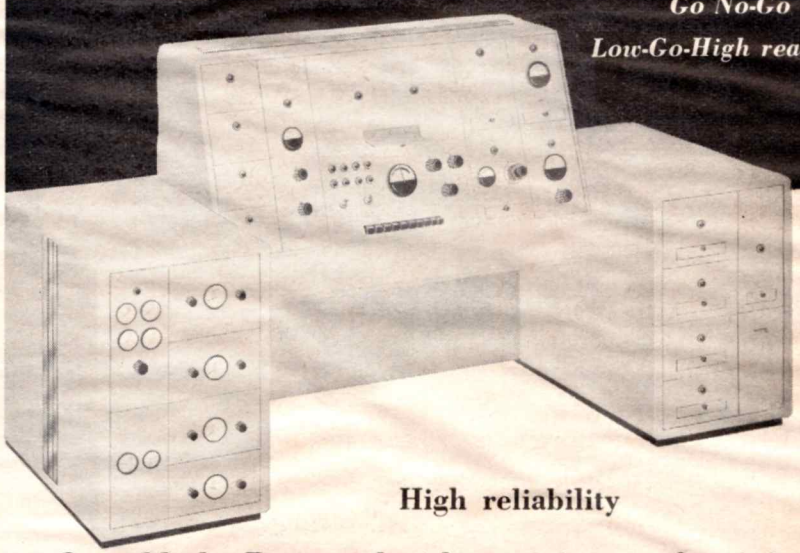
Go No-Go

Low-Go-High readout



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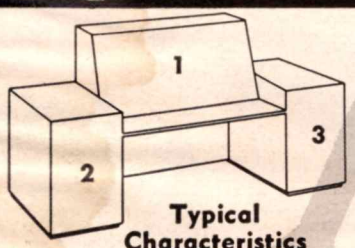

Typical Characteristics

1 Sequencer
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Radar Tester
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Satellite Vehicle

an overlap of messages resembling a conversation with two parties talking at the same time. This is not pleasant but with practice operators could probably be trained to entertain in their consciousness incoming and outgoing information at the same time.

The Earth satellite vehicle or artificial satellite has another general communicative role related to geodesy, namely, its use as an aid to navigation. In its simplest terms, it may be the irreducible minimum satellite being used simultaneously by other people for geodetic triangulation. The regularity of the orbit is the feature that enables men to predict position at a given time and from this to calculate positions on the surface of the globe. If a simple radar or radio beacon could be installed, aided or sustained by solar power, the taking of fixes on the artificial satellite would probably be greatly eased.

It is difficult to see what use this role of the satellite would serve to a spaceship which already has an excellent prospect of the stars and planets. The beacon, though, does suggest a means for conveniently locating the vehicle in the event it is to be serviced or replaced. To the earth-bound, the advantage is fairly obvious. Optical fixes could be taken with great precision by day and radar fixes by night or through overcast, and would be of utility to aircraft and to surface vessels.

END

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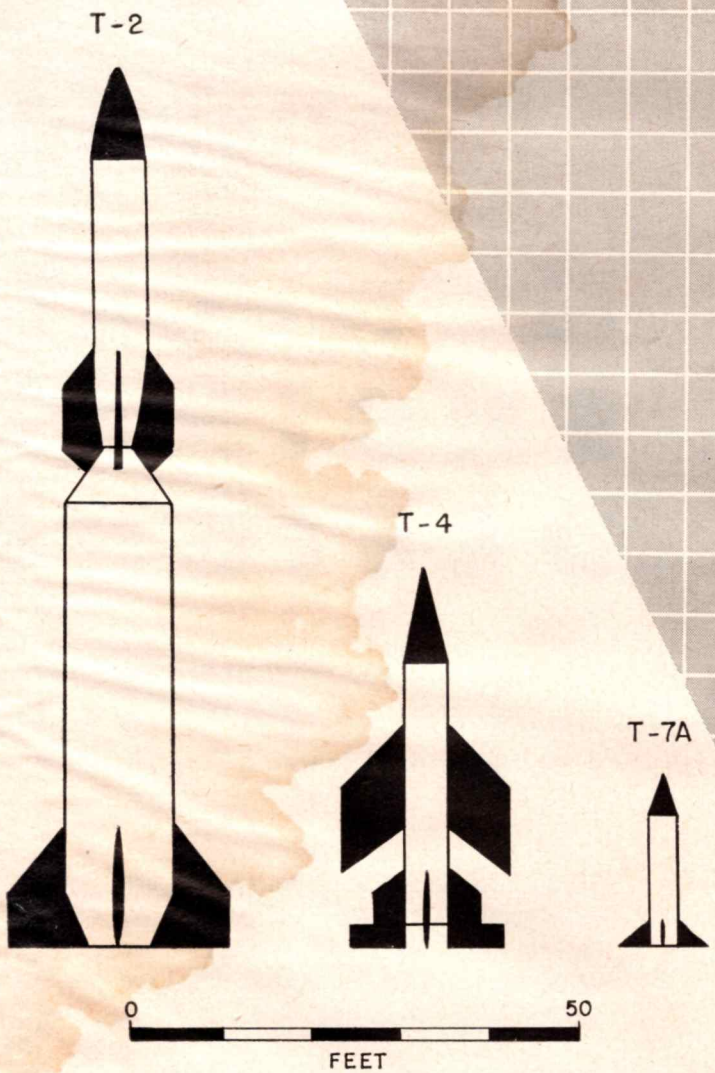

SOVIET MISSILE PROGRESS

Based upon hundreds of related items from foreign press reports, official statements, personal reports and technical publications, the author concludes that the Soviet is progressing rapidly in the missile field and that a powerful missile arm is being forged.

ALFRED J. ZAEHRINGER
President, American Rocket Co.
Wyandotte, Michigan

SOVIET ROCKET INTEREST goes back many years. In 1903, Professor K. E. Ziolkowsky described a liquid propellant rocket engine and in 1914 he presented a mathematical theory of rocket flight. When the Soviet took over Russia, the country continued to follow rocket developments with great interest. Putting security clamps on their programs, they began military rocket development in the mid-thirties. The first products resulted in a wide variety of artillery rockets for the army.

When the Soviet moved into Germany, the Russians acquired a great deal of German rocket and missile technique. In addition, they occupied several German rocket centers, such as Peenemünde. They were able to acquire the services of German technical rocket personnel. These factors resulted in the start of large scale missile projects. Today, the overall missile program ranks with nuclear developments and the expansion of the Soviet air force. Indeed, there also seems to be a vast inter-relation between them.

The large scale program has resulted in a family of missile weapons. These are graphically presented in Table 1, showing initial and subsequent developments.

Like the United States, the probable starting point of large Soviet missile hardware was the A-4 (V-2). In addition to obtaining parts and intact missiles, the Soviet actually resumed production. As many as 1000 A-4's are said to have been produced and used for high altitude research programs, production experience and for training personnel in testing and field operations. Two logical extensions of this program were the immediate development of the improved model T-1 and the T-4 winged counterpart, Figure 1. Further extensions of these are the T-2 long range

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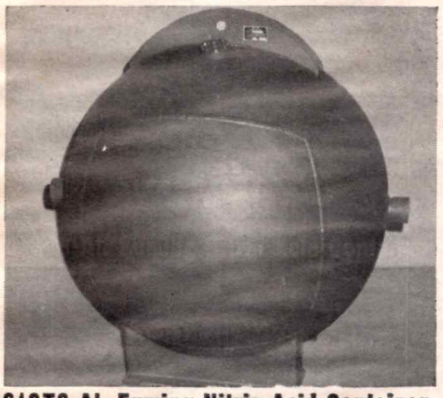

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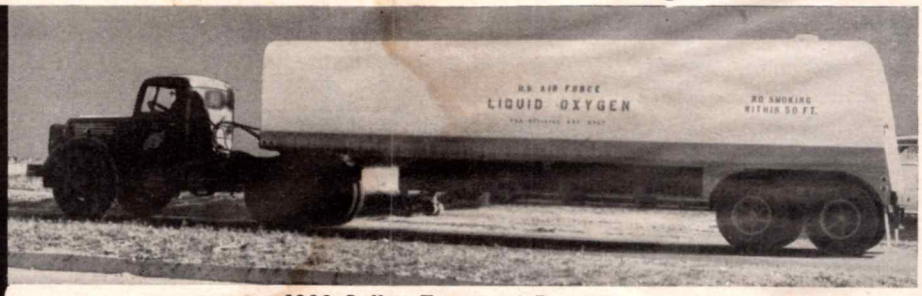

4000 Gallon Transport Dewar

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missile, the T-3 intercontinental ballistic missile and the T-4A supersonic glide missile. These developments probably form the nucleus of Soviet tactical and strategic long range weapons. Other long range weapons were offshoots of the German V-1 and are similar to the *Matador*, *Regulus* and *Snark* weapons systems. For army field use, a variety of artillery and nuclear armed rockets are available in operational numbers.

Included in the Soviet missile program are certain defensive weapons systems. These are mainly anti-aircraft rockets to combat B-52 and B-47 type targets, backed by conventional jet interceptors armed with ballistic and guided aircraft rockets, closer-in defense rocket planes for high altitude interceptions, and finally barrage rockets for last ditch, low altitude defense.

● ● Research Progress

The pioneering work of the early Soviet and acquisition of German experience certainly have been contributing factors to the presently growing Soviet missile stockpile. Important as these factors are, one of the greatest factors in missile expansion has been the growing volume of basic and applied research and use of a technical feedback technique, Table 1. In this manner, findings from the research programs are constantly being fed to the various development programs. Although these programs may sometimes be bold and daring and somewhat wasteful of money and talent, actual hardware production is taking place.

Highlights of Soviet accomplishments are:

1) **Liquid Propellants.** With the mastery of high thrust rocket engines, large rockets are possible. Higher combustion temperatures and pressures have made these large rocket motors possible. Fairly standard oxidant systems (liquid oxygen, nitric acid and hydrogen peroxide) are being used. It appears that peroxide is being used more widely in the Soviet than in the United States. An interesting sidelight of Soviet technical feedback was recently shown when it was reported that a radiation catalyzation process for producing peroxide increased output 70 percent.

2) **Solid Propellants.** The Soviet trend is to use the simpler and cheaper and easily produced high performance composite propellants instead of the older homogeneous (double base) solids. Here again, the Soviet has made some rather large solid propellant motors. The T-7A, for example, may be looked on as an artillery rocket that can be armed with nuclear warheads and that has the simplicity of the *Honest John* (solid propellant) and the range of the *Corporal* (liquid propellant). The newer composite propellants with reduced temperature sensitivities are finding useful applications in ballistic and guided aircraft rockets that can operate in the rigors of the Soviet northland.

3) **Air-Breathing Powerplants.** It is certain that the Soviet has continued development of jet propelled weapons. The country now has at least four naval attack fleets; each fleet is equipped with 800 to 900 jet aircraft and 90 missile launching submarines. It also has 370 to 400 submarines, 150 of which are long range types. One missile-carrying submarine is being launched each week. These vehicles could easily carry the J-3 cruise missile.

Although information about Soviet progress in pulsejet and ramjet powerplants is somewhat meager, judging by the efforts being carried on in the turbojet field and by the research in the combustion field, American investigators conclude that this propulsion region is not neglected.

4) **Guidance.** The guidance work is as clouded by security as is ours. In view of the missiles developed by the Soviet, there is every indication that great efforts have gone into this field. Radar stations (for missile test work and as a part of the Soviet air defense system) have been reported throughout the Soviet, and the high level of electronic and related talent is surely being employed in ventures other than the production of domestic radio.

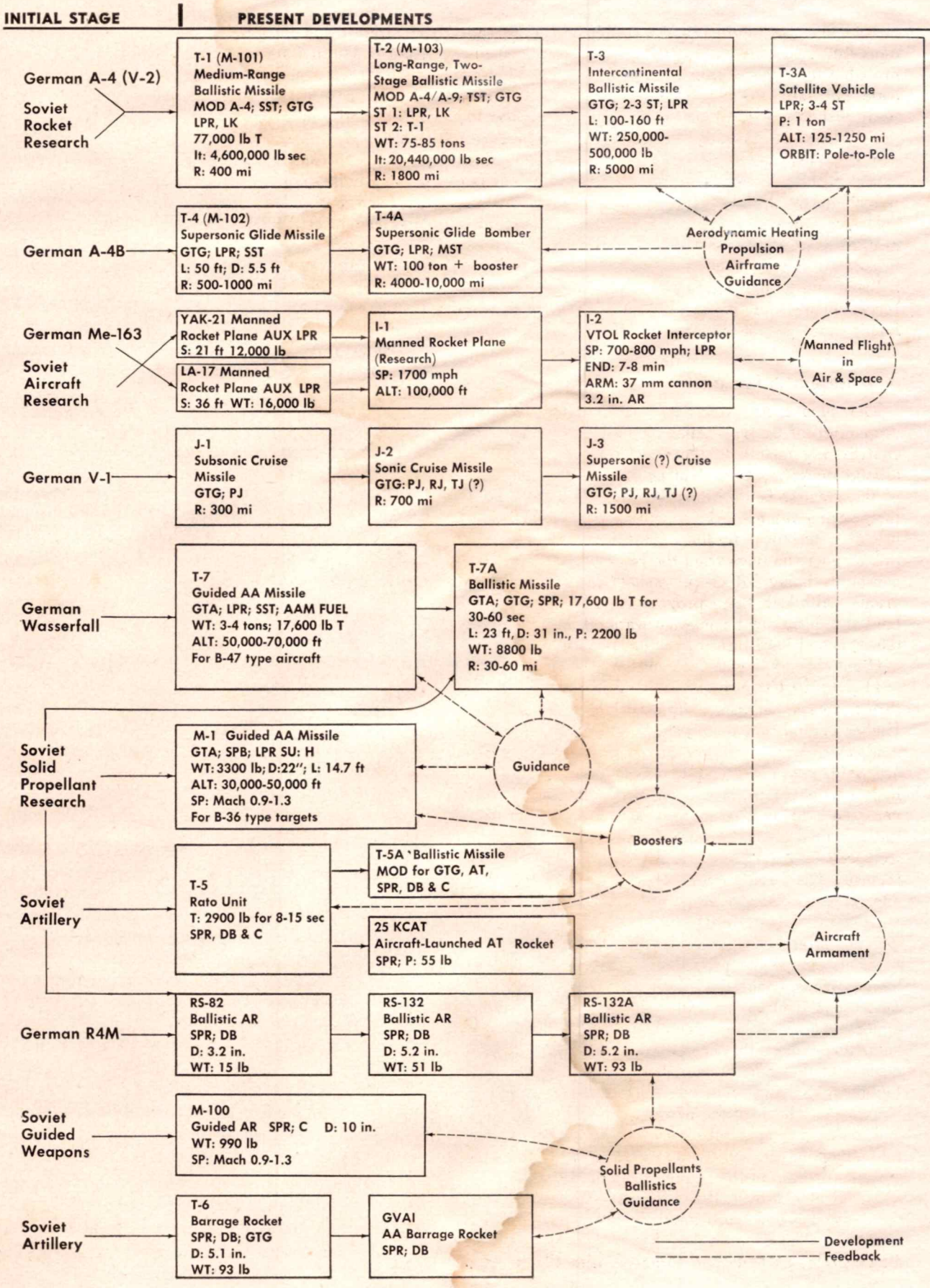
● ● Present Status

With the expansion of the Soviet air force after the last war, new propulsion regions were vigorously investigated. The accomplishments in the jet aircraft field are much better defined than with ramjets or rockets. With the latter, application of on-the-shelf German rocket units to Soviet aircraft was attempted early. This finally resulted in an operational VTOL rocket plane which is said to be well entrenched in the Soviet defense scheme. Whether the manned antipodal rocket bomber project (T-4A) has advanced much further than it did in Germany is not well known; but it would fit well into the overall scheme as an adjunct to the intercontinental ballistic missile.

SYMBOLS →

I	Interceptor	LK	Liquid oxygen-kerosene propellant
J	Jet	LPR	Liquid propellant rocket
M	Model	MOD	Modified
T	Type	MST	Multi-stage
AA	Antiaircraft	P	Payload
AAM	Nitric acid-amine propellant	PJ	Pulsejet
ALT	Altitude	R	Range
AR	Aircraft rockets	RATO	Rocket assisted takeoff
ARM	Armaments	RJ	Ramjet
AT	Anti-tank	S	Span
AUX	Auxiliary power	SP	Speed
B	Booster	SPB	Solid propellant booster
C	Composite	SPR	Solid propellant rocket
D	Diameter	SST	Single stage
DB	Double base	ST	Stage
END	Endurance	SU	Sustainer
GTA	Ground-to-air	T	Thrust
GTG	Ground-to-ground	TJ	Turbojet
H	Hydrogen peroxide propellant	TST	Two stage
It	Total impulse (lb sec)	WT	Total weight
L	Length		

The Soviet Missile Picture


INITIAL STAGE
PRESENT DEVELOPMENTS
German A-4 (V-2)
Soviet Rocket Research
T-1 (M-101) Medium-Range Ballistic Missile MOD A-4; SST; GTG LPR, LK 77,000 lb T It: 4,600,000 lb sec R: 400 mi
T-2 (M-103) Long-Range, Two-Stage Ballistic Missile MOD A-4/A-9; TST; GTG ST 1: LPR, LK ST 2: T-1 WT: 75-85 tons It: 20,440,000 lb sec R: 1800 mi
T-3 Intercontinental Ballistic Missile GTG; 2-3 ST; LPR L: 100-160 ft WT: 250,000-500,000 lb R: 5000 mi
T-3A Satellite Vehicle LPR; 3-4 ST P: 1 ton ALT: 125-1250 mi ORBIT: Pole-to-Pole
German A-4B
T-4 (M-102) Supersonic Glide Missile GTG; LPR; SST L: 50 ft; D: 5.5 ft R: 500-1000 mi
T-4A Supersonic Glide Bomber GTG; LPR; MST WT: 100 ton + booster R: 4000-10,000 mi
Aerodynamic Heating Propulsion Airframe Guidance
German Me-163
Soviet Aircraft Research
YAK-21 Manned Rocket Plane AUX LPR S: 21 ft 12,000 lb
LA-17 Manned Rocket Plane AUX LPR S: 36 ft WT: 16,000 lb
I-1 Manned Rocket Plane (Research) SP: 1700 mph ALT: 100,000 ft
I-2 VTOL Rocket Interceptor SP: 700-800 mph; LPR END: 7-8 min ARM: 37 mm cannon 3.2 in. AR
Manned Flight in Air & Space
German V-1
J-1 Subsonic Cruise Missile GTG; PJ R: 300 mi
J-2 Sonic Cruise Missile GTG: PJ, RJ, TJ (?) R: 700 mi
J-3 Supersonic (?) Cruise Missile GTG; PJ, RJ, TJ (?) R: 1500 mi
German Wasserfall
T-7 Guided AA Missile GTA; LPR; SST; AAM FUEL WT: 3-4 tons; 17,600 lb T ALT: 50,000-70,000 ft For B-47 type aircraft
T-7A Ballistic Missile GTA; GTG; SPR; 17,600 lb T for 30-60 sec L: 23 ft, D: 31 in., P: 2200 lb WT: 8800 lb R: 30-60 mi
Guidance
Soviet Solid Propellant Research
M-1 Guided AA Missile GTA; SPB; LPR SU: H WT: 3300 lb; D: 22"; L: 14.7 ft ALT: 30,000-50,000 ft SP: Mach 0.9-1.3 For B-36 type targets
Boosters
Soviet Artillery
T-5 Rato Unit T: 2900 lb for 8-15 sec SPR, DB & C
T-5A Ballistic Missile MOD for GTG, AT, SPR, DB & C
25 KCAT Aircraft-Launched AT Rocket SPR; P: 55 lb
Aircraft Armament
German R4M
RS-82 Ballistic AR SPR; DB D: 3.2 in. WT: 15 lb
RS-132 Ballistic AR SPR; DB D: 5.2 in. WT: 51 lb
RS-132A Ballistic AR SPR; DB D: 5.2 in. WT: 93 lb
Soviet Guided Weapons
M-100 Guided AR SPR; C D: 10 in. WT: 990 lb SP: Mach 0.9-1.3
Solid Propellants Ballistics Guidance
Soviet Artillery
T-6 Barrage Rocket SPR; DB; GTG D: 5.1 in. WT: 93 lb
GVAI AA Barrage Rocket SPR; DB
Development
Feedback

Re-design of first Rolls-Royce turbojet engine gave 40 percent power increase. Further work on air-cooled turbine blades and nozzle guide vanes expected to yield even more engine power and less specific fuel consumption.

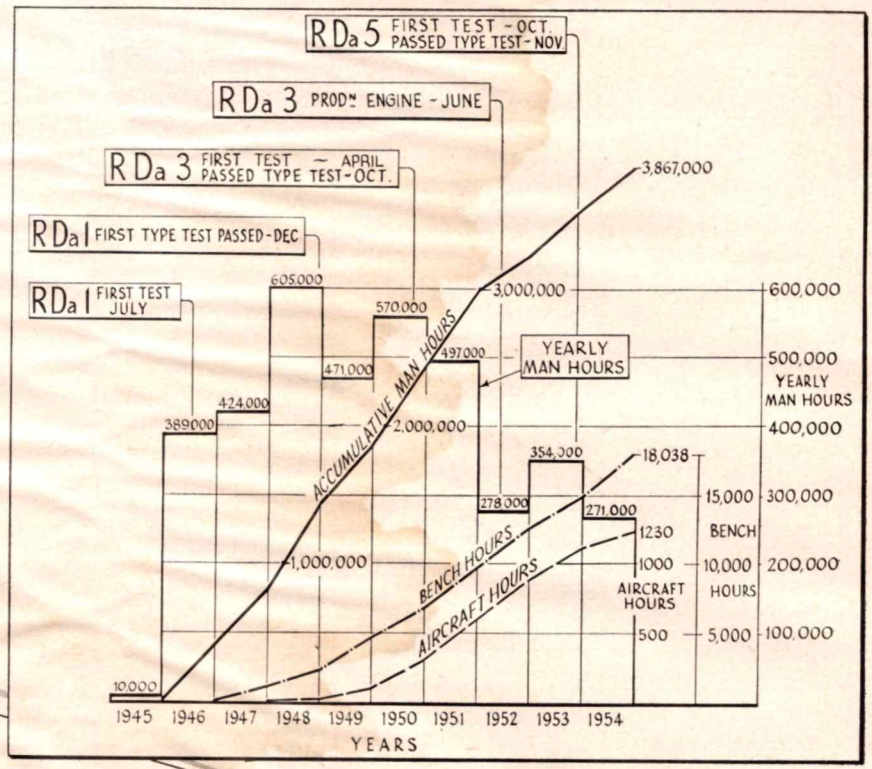


Figure 1—Time required to manufacture and develop *Dart* turboprop engines.

Performance Development of

THE DART

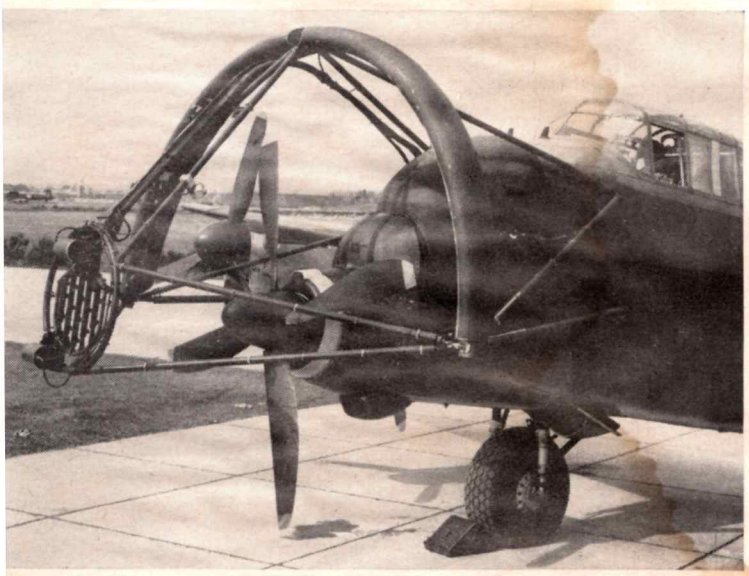


Figure 2—Spray grid for de-icing testing.

THE DESIGN of the *Dart* started in 1945 as a 1000 horsepower engine for a single-engine military trainer. The first engine was run July 1946. Although a type test was completed on this engine in December 1948, drastic re-design resulted in an engine called the RDa3. This engine passed a type test in October 1950 at a 1400 horsepower rating. The engine, after minor changes, went into production as the *Dart* 505 in June 1952. Figure 1 shows that about 12,000 hours of bench development-running were accumulated prior to delivery of the first production engine.

The time scale may be considered a little long; but this engine was the first turboprop to be taken through to production; further, there was a period when the engine was not receiving top priority.

Development of a satisfactory de-icing system covering all conditions of flight takes considerable time; approximately 400 flying hours were used to get the *Dart* de-icing system to its present standard. The de-icing development required a special water-spray

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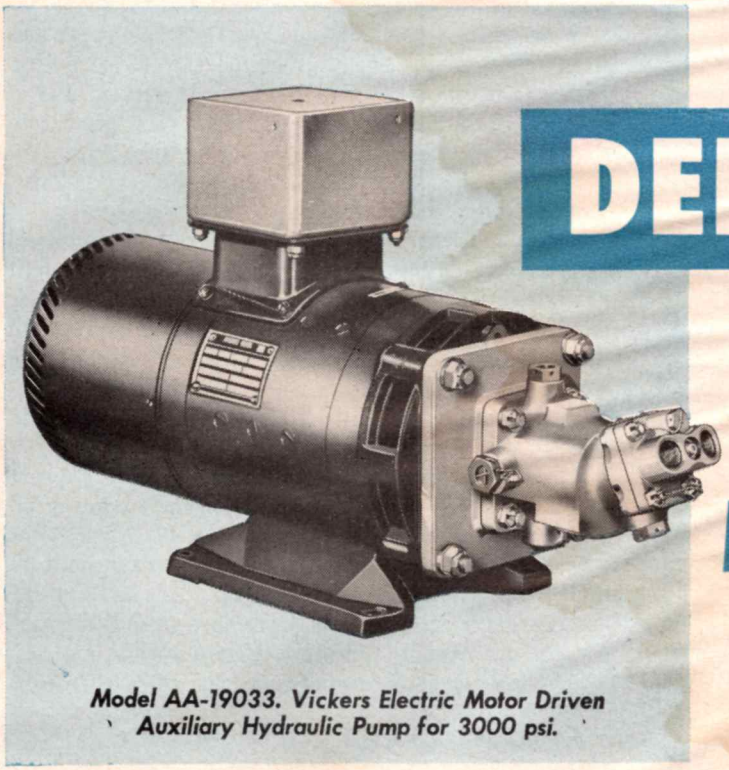
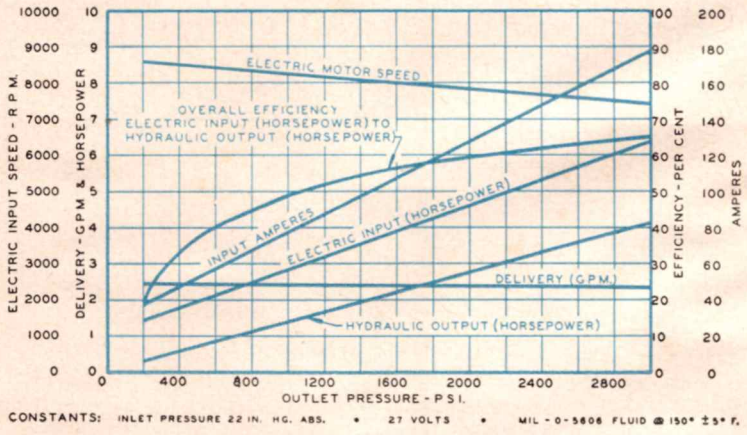


Model AA-19033. Vickers Electric Motor Driven Auxiliary Hydraulic Pump for 3000 psi.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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

For further information circle Reader Reply No. 45

grid fitted to an installation on a four-engine flying test bed, shown in Figure 2.

To further aid development of satisfactory de-icing of the rotating blades, Rolls-Royce used a rotor icing rig in which a single stage of rotors could be run at engine speed. The layout is shown in Figure 3.

The *Dart* accumulated 14,500 hours flying time before the first aircraft went into regular passenger-carrying operation. Of this, 9000 hours were accumulated on the two *Viscount* prototypes, which is an unusually high figure for prototypes. One reason stems from the *Viscount* prototypes having been used for preliminary route flying. In addition, *Dart* engines were fitted to two C-47's which were operated by BEA as freighters; close to 4000 hours flying time were accumulated here. The route flying of the C-47's was most valuable because airline operation of the engine brought out troubles that Rolls-Royce had not previously uncovered.

Experience with fire extinguishing arrangements has shown that often it is small faulty details that let the system down. This led Rolls-Royce to build a fire tunnel. A complete engine nacelle and its associated wing structure can be mounted, and a fire started with air flow in the tunnel, Figure 4.

The tunnel is ten feet in diameter and can generate air speeds up to 350 mph. by using two *Nene* engines as ejectors. This tunnel has been valuable for devising fire extinguishing systems and for zoning turbine engines. It is also used to help establish minimum ventilation flows in the various zones; ventilation is paid for in fuel consumption resulting from the drag involved—a point sometimes overlooked.

It is useful to see how the *Dart's* development has been reflected by behaviour of the engine in service. Figure 5 shows statistics of failures in service due to engine defects that involve removal of the engine from the airframe, either at base or away from base; the figure also shows the rate at which the engine overhaul life has been increased.

Fortunately the turboprop lends itself to continued performance development. This is a result of the shaft horsepower being the difference between the power developed by the turbines and the power required to drive the compressor; thus, any efficiency gain in these components is significant when expressed as a percentage increase in shaft horsepower or decrease in specific fuel consumption.

As an example, the *Dart* turbines develop approximately 4500 horsepower, the compressor takes 3000 horsepower, and the difference of 1500 horsepower appears at the shaft. This means that a one percent improvement in turbine efficiency leads to a three percent increase in shaft horsepower and a three percent decrease in specific consumption; a one percent improvement in compressor efficiency leads to a

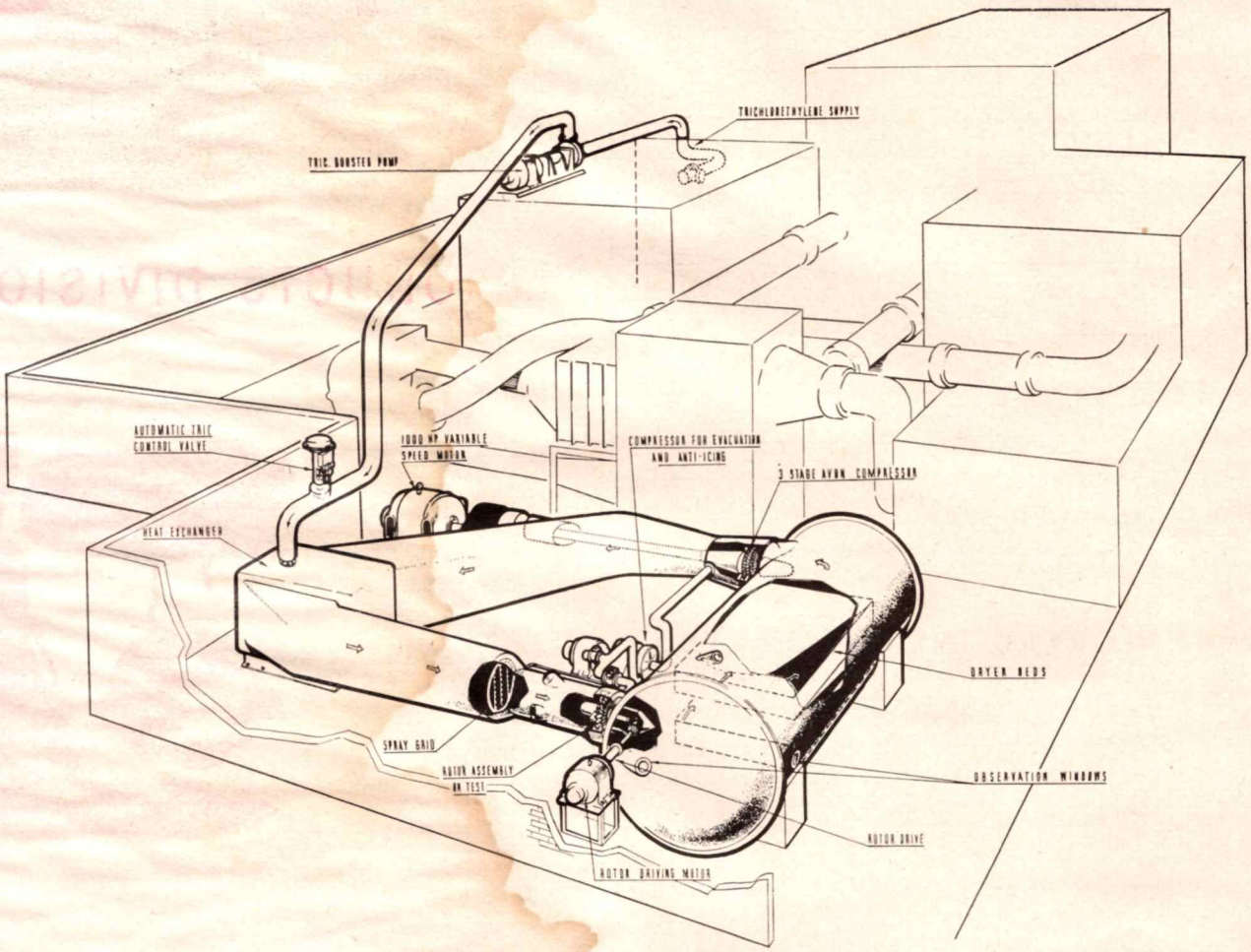

Figure 3—Rotor icing test rig.

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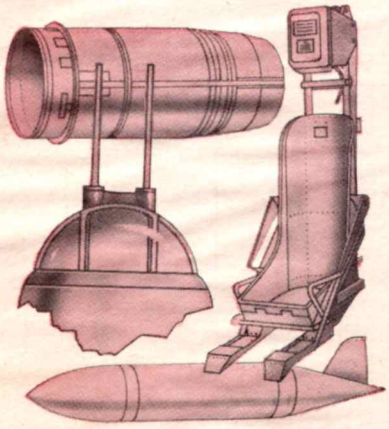

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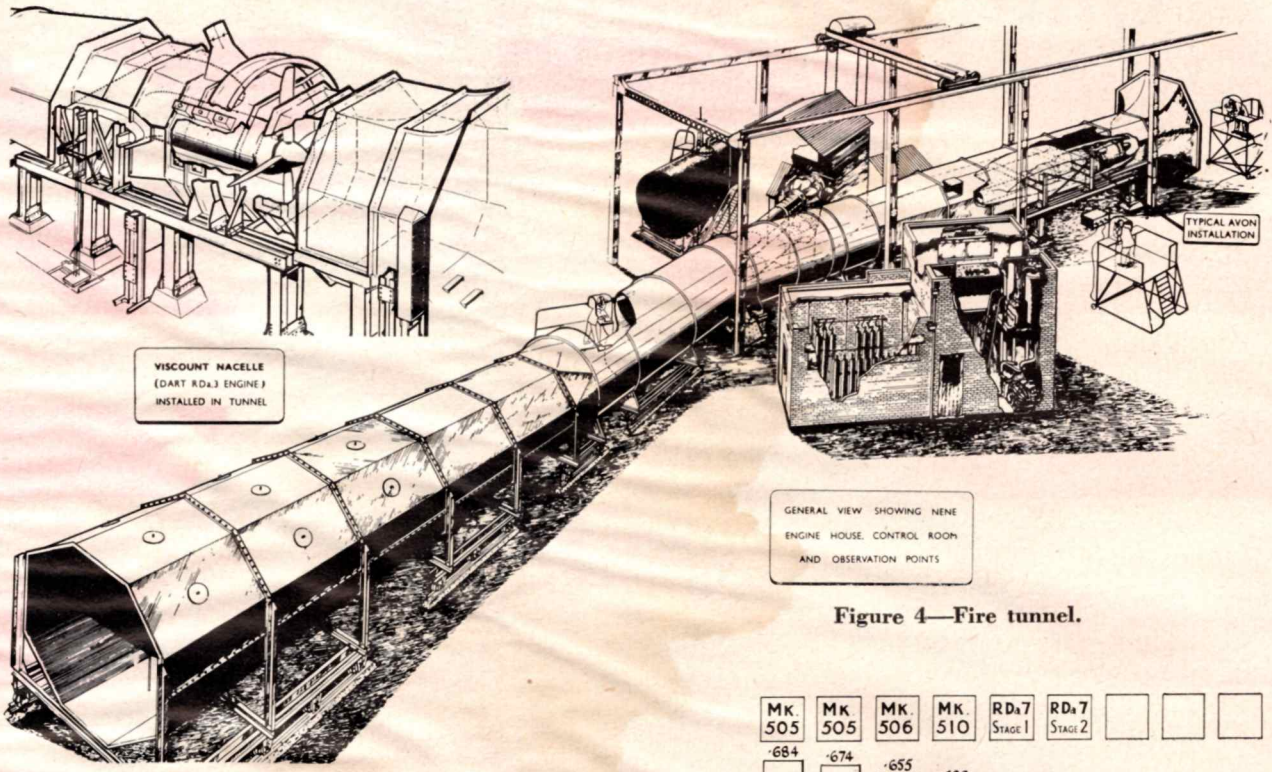


Figure 4—Fire tunnel.

two percent increase in shaft horsepower and a two percent decrease in specific consumption. Performance development is shown in Figure 6.

There is obviously a limit beyond which it will be difficult to improve component efficiencies; but there is scope for developing engines to operate at higher temperatures. The reward obtained by being able to operate an engine at higher flame temperatures is shown in Figure 7. END

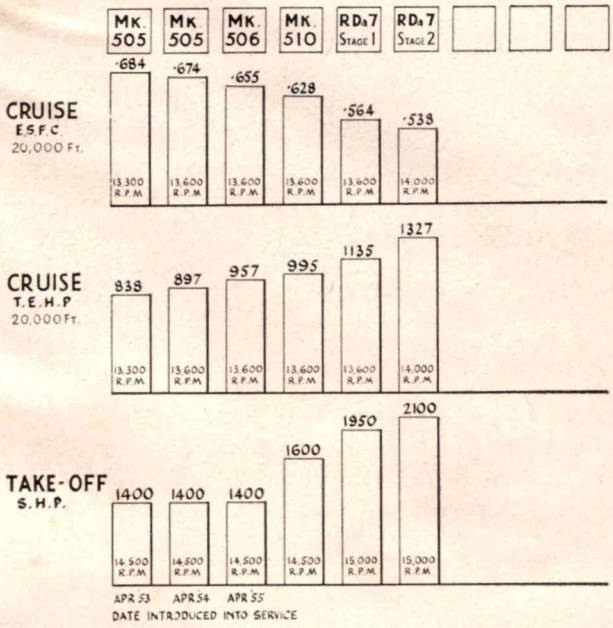


Figure 6—*Dart* performance development.

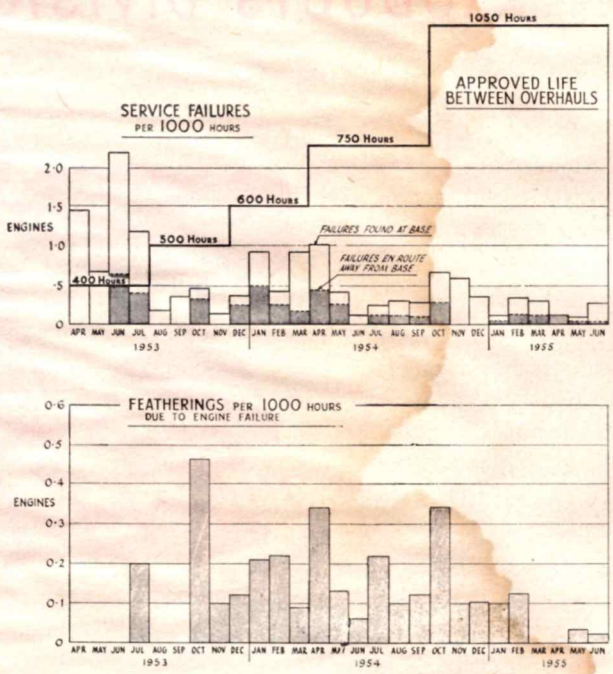


Figure 5—*Dart* engine experience.

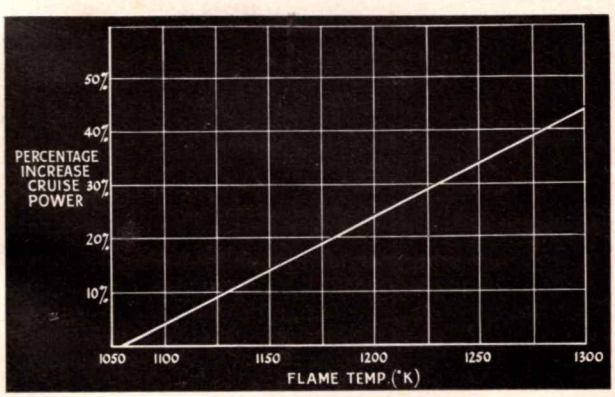
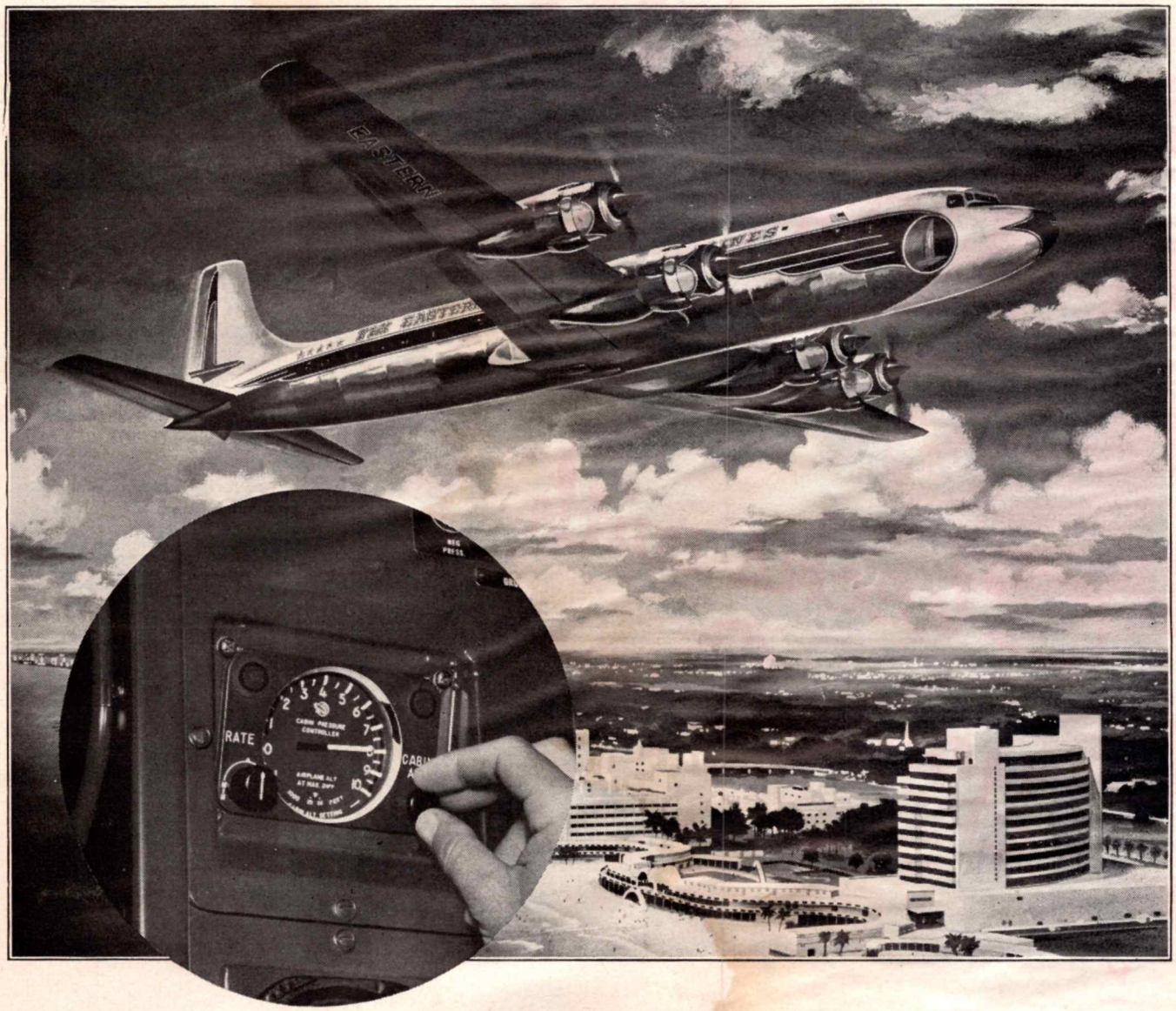


Figure 7—Effect of flame temperature on cruise power of a turboprop engine.



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NEW BOOKS

TECHNICAL AERODYNAMICS, third edition, Karl D. Wood, 1955. Published by the author, distributed by Ulrich's Book Store, Ann Arbor, Michigan. Lithoprinted, 519 pp, $7.50.

The author states that the object of the third edition, as with the preceding two editions, is to provide a course of study for the engineering student (or a refresher course for the practicing engineer) that will help fit him to make the performance, stability and aerodynamic design calculations of current importance in the aircraft industry. On this basis, the edition reduces the attention paid to light planes and seaplanes and increases the attention paid to jet-propelled planes and missiles, and to helicopters and helicopter-airplane combinations.

For further information circle
Reader Reply No. T-140

GAS TURBINES AND JET PROPULSION, sixth edition, G. Geoffrey Smith, revised and enlarged by F. C. Sheffield, 1955, Philosophical Libriary, New York, 412 pp., $15.

The principles and history of jet propulsion are first discussed. The book then deals with the main technical aspects of jet propulsion including design and performance, components, fuels and fuel systems, metallurgical problems, research, testing and maintenance. The various types of British, American, Canadian and European aircraft gas turbines available or under development are surveyed. Later chapters examine special applications such as rockets and helicopters.

For further information circle
Reader Reply No. T-141

ROTORCRAFT, R. N. Liptrot and J. D. Woods, 1955, Butterworths Scientific Publications, London. 172 pp., 32s.

This book is an introduction to the theory and practice of rotary wing aircraft, explaining the fundamentals of rotorcraft engineering in a simple and practical manner. The subject matter is presented in a readable and

useful way so that the book can be a practical help to the engineer in his daily work, as a reference work and guide.

For further information circle
Reader Reply No. T-142

AUTOMATIC CONTROL BIBLIOGRAPHY, Warren F. Wade and Emory N. Kemler, 1955, Summary Reports, P. O. Box 176, Spring Park, Minnesota, 331 pp.

This bibliography attempts to summarize the American and English publications relating to the automatic control field, primarily for the period since 1900. The abstracts do not attempt to evaluate the importance of the articles, but rather to convey a general idea about the type material in the articles.

For further information circle
Reader Reply No. T-143

THE FORESEEABLE FUTURE, Sir George Thomson, 1955, Cambridge University Press, New York. 166 pp., $2.50.

What will it be like a hundred years from now? What will science have done for (or to) us? Sir George Thomson risks a forecast. Our present knowledge of the universe can be reduced to a few principles. If any one is added or discarded, or even radically changed, the unforeseen—and a new scientific era—will be upon us. If not, then we can foresee the broad lines of technological advance. This is what this book does.

For further information circle
Reader Reply No. T-144

ACROSS THE HIGH FRONTIER, *The Story of a Test Pilot* — Major Charles E. Yeager USAF, William R. Lundren, William Morrow & Co., New York. 288 pp., $3.75.

This is the story of an airplane—the X-1—through all the thousands of stages of design, manufacture and testing that go into the making of a pioneer plane. It is also the story of Yeager's life, his wartime career as a fighter pilot and his dramatic escape from the Nazis, his experiences as an experimental test pilot—and his momentous victory in the air when he becomes the first human to crash through the sonic barrier.

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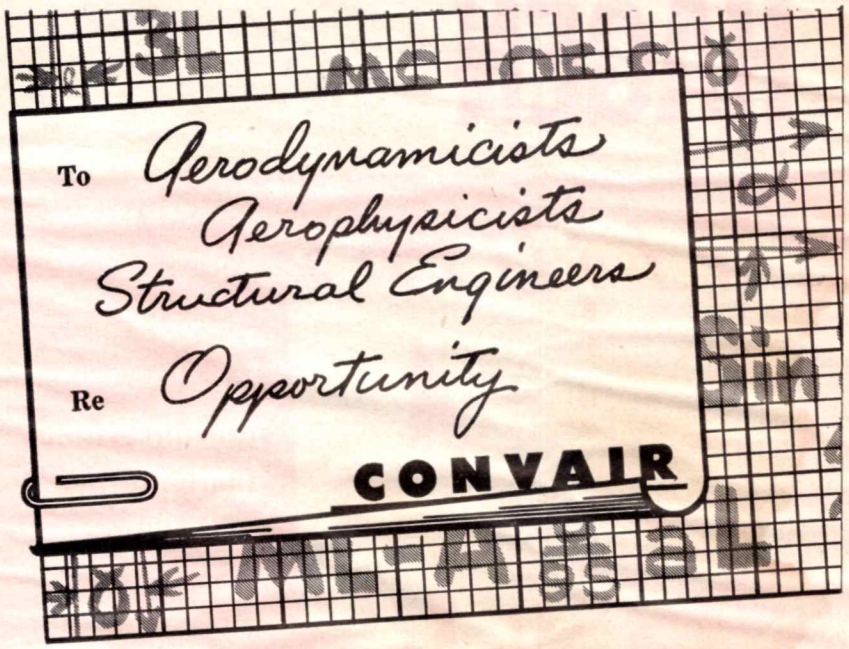

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International Calendar

Dec. 12-16—NUCLEAR ENGINEERING and Science Congress, sponsored by Engineers Joint Council, Public Auditorium, Cleveland.

Dec. 15-17—Fall Meeting, USA National Committee, URSI (INTERNATIONAL RADIO SCIENTIFIC UNION), University of Florida, Gainesville, Fla.

Jan. 23-26—Seventh Plant MAINTENANCE & ENGINEERING Conference will be held at Convention Hall, Philadelphia, Pa.

Feb. 1-2—WELDING IN NUCLEAR REACTORS AND ROCKETRY will be the subject at the Midwest Welding Conference, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

Feb. 2-3—National Symposium on MICROWAVE TECHNIQUES, sponsored jointly by the Professional Group on Antennas and Propagation, the Professional Group on Microwave Theory and Techniques and the Philadelphia Section of the Institute of Engineers, Philadelphia, Pa.

Feb. 7-9—11th Annual SPI REINFORCED PLASTICS Division Conference, The Society of the Plastics Industry, Inc., Hotel Chalfonte-Haddon Hall, Atlantic City, N. J.

Mar. 8-9—14th Annual SPI Canadian Conference, The Society of the PLASTICS INDUSTRY CANADA, Inc., Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada.

Mar. 12-16—1956 CORROSION SHOW held in conjunction with the 12th Annual Conference of the National Associaiton of Corrosion Engineers, Hotel Statler, New York, N. Y.

Mar. 22-23—Symposium on the EXTRACTION METALLURGY of Some of The Less Common Metals, The Institution of Mining and Metallurgy, Salisbury House, Finsbury Circus, London, Eng.

Mar. 27-Apr. 2—13th Annual Pacific Coast Section Conference, The SOCIETY OF THE PLASTICS INDUSTRY, Inc., St. Francis Hotel, San Francisco, Calif. and S.S. "Lurline" to Honolulu.

Apr. 4-8—2nd Internaitonal Congress of RADIOPHOTOGRAPHY, The Congress, Rome, Italy.

Apr. 5-7—4th General Assembly of Italian Society of GEOPHYSICS AND METEOROLOGY, Genoa, Italy.

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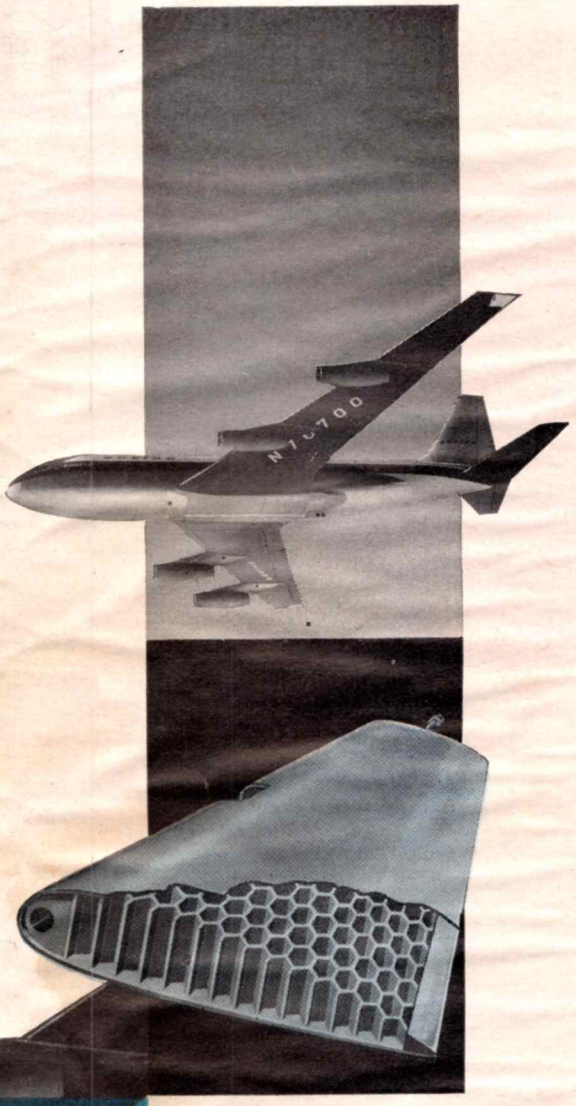

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TRADE LITERATURE

For further information about Trade Literature reviewed below, make use of our Reader Reply Service. You may obtain copies by circling the appropriate number on the Reader Reply Card opposite page 68.

Blast Cleaning Machine. Bulletin No. 100-D describes table-type airless blast cleaning machines designed for cleaning work that does not have too many pocket or vertical edges, including castings, forgings, heat treated parts, weldments or stampings. Also used for preparation of metallic parts for galvanizing, rubberizing, glass coating, painting, enameling and plasticizing. Ideal for flat or fragile work which requires careful handling. Wheelabrator Corp. (T-1)

Rubber Parts. Comprehensive data chart about rubber parts and rubber covered metal parts such as slips, clamps and grommets. Automotive Rubber Company. (T-2)

Jig Borers. 28 pp bulletin describes advantages of Electrolimit jig borers such as Electrolimit measuring system, precision preloaded ball roll quill, electronically controlled milling feeds, centralized controls and open side construction. Pratt & Whitney. (T-3)

Shell Molding Machine. 12 pp illustrated brochure covers ESCO Shellcast facilities and products. Describes high speed, automatic heating and curing performed by the Shellcast. Electric Steel Foundry. (T-4)

Plastics. 20 pp brochure discusses applications of fluorocarbon plastics and gives word and picture story of the company, fabricators of Teflon, Kel-F, Bakelite Fluorothene and similar engineered plastics. United States Gasket. (T-5)

Vibration Measurement. 64 pp illustrated booklet covers the meaning of vibration terms, description of vibration-measuring instruments, procedures, typical examples and interpretation of results. General Radio Company. (T-6)

Noise Suppression. 7 pp illustrated brochure describes noise suppression equipment for engine test cells and sound-treated airplane run-up stands. Kittell-Lacy. (T-7)

Wall Chart. 22″ x 27″ three color wall chart is designed to assist engineers in quickly specifying AN connectors for a wide range of applications. Describes how to specify the complete connector assembly, how to select the right AN connector, and covers code of contact sizes, shell dimensions and availability check list and shell data. The Deutsch Company. (T-8)

Metal-working Presses. 12 pp bulletin, No. 3201, illustrates and describes metal working presses for extrusion, metal forming and drawing, forging, bending, flanging, crimping and straightening, and pipe fabricating equipment. Also describes broad range of application of these presses with typical installation illustrations and individual tables of specifications. Baldwin-Lima-Hamilton. (T-9)

Hydraulic and Air Components. Catalog, 36 pp No. 555, describes features, specifications and applications of pumps, cylinders, jacks, braces and other units. Star Jack. (T-10)

Aluminum Pipe. 18 pp booklet gives characteristics of aluminum pipe and fittings along with specifications and descriptions of appropriate fittings for various applications and methods of installation. Aluminum Company of America. (T-11)

Printed Circuitry. 12 pp second edition of bulletin on printed circuitry for electrical and electronic systems. Also gives specifications on types and grades of copper-clad phenolite used as base material for these circuits and discusses new glass cloth epoxy resin recommended for circuits requiring high heat resistance. National Vulcanized Fibre. (T-12)

Equipment and Cleaning Techniques. Illustrated 28 pp bulletin No. 10,-000-G, shows how to select the proper method, machine and material for cleaning, degreasing, decarbonizing, washing, bonderizing, stripping, drying, blackening, phosphatizing, rust proofing, pickling, coating and processing of metal parts. Magnus Chemical. (T-13)

Portable Gamma Ray Projector. 24 pp booklet describes a new portable gamma ray projector used in industrial radiography. Discusses radioactive materials, isotopes, kinds of radiation, and hard and soft rays and contains a gamma ray intensity and film exposure guide designed to help the radiographer locate and schedule work to minimize the disruption of other work and predict unsafe working areas. Metal and Thermit Corp. (T-14)

Radiant Heating. 32 pp illustrated report discusses basic differences between convective and radiant heating, reviews typical radiant heating and snow melting installations at airports and analyzes installation data with recommendations for proper selection of materials. A. M. Byers. (T-15)

Actuator. Catalog 22 describes new actuator design for precise position control at high response speeds for valves, slides, gates and other mechanisms. Weighing & Control Components. (T-16)

Couplings. Illustrated 78 pp catalog is designed as a source of reference on flexible aircraft plumbing. Catalog gives hose and fitting sizes, operating pressures, temperatures and other engineering data. Also includes guides for selection and installation of flexible hose, fittings, hose assemblies and self-sealing couplings. Aeroquip. (T-17)

Plastic. Descriptive manual, 20 pp gives illustrations showing possible applications for "Scotchply" reinforced plastic in various industrial fields as well as in machining and handling, molding, sanding and grinding, sawing, milling, shaping, turning, drilling and tapping. Also features charts describing the mechanical, electrical, chemical resistance and thermal properties of the material. Minnesota Mining and Manufacturing. (T-18)

Couplings. 12 pp illustrated pamphlet is designed to help solve power transmission problems. Discusses the use of flexible couplings in mill service, high speed turbines, hydraulic presses, power supply, marine service, aircraft power drives, and other fields requiring high speed, high torque and high misalignment capacity. American Flexible Coupling. (T-19)

Resistors. Illustrated catalog describes new sub-miniature wire-wound resistor in either inductive or non-inductive windings from ¼ inch to ¾ inch in length, any resistance value desired, and in any standard tolerances, including precision tolerances. Precision Resistor Co. (T-20)

Test Bars. Illustrated booklet discusses the design and making of aluminum alloy and copper base test bars. Also gives melting and pouring procedures, temperatures, pouring procedures and shake-put times for various alloys. The George Sall Metals Co. (T-21)

Aerial Photographic Equipment. 15 illustrated data sheets describe such aerial photographic equipment as autocollimators, remote - controlled aerial camera mounts, data-recording camera, verticle view interval finders and photosonics. Gordon Enterprises. (T-22)

Oscillograph. 12 pp descriptive bulletin, No. 1521B, illustrates type 5-116 recording oscillograph and its various uses such as in product-design analysis during development and testing of helicopters, vibration and stress analysis in engine and chassis design, environmental and qualification testing of landing gear prototype and production mod-

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For further information circle Reader Reply No. 39

els and shock analysis tests. Consolidated Engineering. (T-23)

Recording and Playback System. Illustrated 25 pp bulletin, No. 1651A, describes Consolidated's new magnetic tape recording and playback system for recording stress, pressure, temperature and vibration. Also discusses various choices of modulation techniques. Consolidated Engineering. (T-24)

Tool Steel. 8 pp booklet is first edition of a series of tool stock lists giving information on composition, grades and sizes of steels available in area warehouses. Allegheny Ludlum Steel. (T-25)

Automatic Circuit Analyzer. 8 pp descriptive bulletin gives applications of DIT-MCO model 80 circuit analyzer. Discusses automatic and complete testing of complex electrical systems in manufacture, maintenance and overhaul of aircraft, guided missiles, radar, computers, relay and telephone systems, and servomechanisms. DIT-MCO. (T-26)

Tubes. Illustrated, 10 pp booklet describes RCA "Special Red" tubes for use in industrial applications. The manufacturer says these tubes are designed for use where stability, long life, rigid construction and dependability are of paramount importance. Radio Corporation of America. (T-27)

Screen Process Printing on Plastics. 5 pp illustrated bulletin describes equipment, procedures and paints used in screening on plastics. LOGO, Inc. (T-28)

Broaching Machines. Descriptive bulletin VCA-55, 4 pp, gives details and features of the Colonial continuous broaching machine, covering construction, operation, controls and specifications. Colonial Broach and Machine Co. (T-29)

Springs. Illustrated 8 pp brochure describes various precision mechanical springs. Also contains illustrated directions for specifying springs. Automatic Spring Coiling. (T-30)

Neoprene. 8 pp booklet "Neoprene Notebook" gives facts about neoprene including effects of sun, atmosphere and climate on rubber as well as various applications of this material. E. I. DuPont DeNemours & Co. (T-31)

Punched Tape Control System. Illustrated 8 pp booklet describes the operating principles of "Binotrol," a punched tape control system, and its application on Jones and Lamson turret lathe to make it completely automatic. Preparation of the punched tape, application of binary number coding to the lathe's functions and advantages of the new lathe are also discussed. Barnes Engineering Company. (T-32)

Heat Detector Cell Accessories. Illustrated 4 pp bulletin TDS-HDCA. The Servotherm detector cells, preamplifiers, power unit, amplifier and Servofraz glass are components

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For further information circle Reader Reply No. 7

THESE RADAR COMPONENTS *fabricated by Lavelle help make advanced concepts in the use of electronics a working reality. Lockheed's unique picket plane is such—a complete airborne radar search and control center for both offensive and defensive operations. Images fed by the "piggy-back" radar to the control center radarscope give altitudes of all aircraft within radar range.*

Radar Reflector and Reflector Support for the plane's complex height finding system were designed and produced by Lavelle in close cooperation with Philco Corporation. Like the intricate Radar Console housing, also made by Lavelle for Philco, they are typical of the precision components fabricated by Lavelle for leading electronics, jet engine, and aircraft manufacturers.

A new brochure describes Lavelle's specialized fabricating facilities. Write for a copy without obligation.

Lavelle

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For further information circle Reader Reply No. 22

used in infrared detection, measurement, analysis and control systems. All or part are units specified for laboratory and industrial instruments as well as military devices. Servo Corporation of America. (T-33)

Materials Handling. 4 pp folder, first of a new series, is designed to help manufacturers select the right materials handling equipment for their specific operations. Gives specifications of the Model 500 fork lift truck as well as schematic drawings and diagrams to point out capacity, load center, turning radium, speed of travel and lift and other performance data. Towmotor Corp. (T-34)

Positioning Control System. Illustrated, 2 pp bulletin, discusses the control problem of positioning test models in blowdown wind tunnels. This unit is basically designed to produce precise electrical positional command signals. Features include high impedance input to eliminate loading of programmer bridge circuit to hold linearity or programmer, built-in emergency high speed fail-safe circuit, permitting return of sector to home position in ½ second without use of the electronic circuitry and plug-in construction for simplicity of wiring and maintenance. CDC Control Services. (T-35)

Lubricants. Bulletin 103A, 4 pp, lists various types of molybdenum disulfide lubricants and features an explanation, with diagrams, of the applications of this lubricant in instances where there is extreme bearing pressure and high, low and normal temperatures present. Also included is a selector chart which describes each Molykote type, the kind of carrier used in it, the temperature range in which it operates best and the proper method of application. The Alpha Molykote Corporation. (T-36)

Alloys and Fluxes. Illustrated folder discusses the increasing number of problem-solving alloys and fluxes offered for work on steel in maintenance, production and construction. Also discusses uses and applications of these alloys and fluxes for welding, brazing, soldering and cutting steel. All-State Welding Alloys Co. (T-37)

Electronic Test Instruments. Illustrated 8 pp catalog describes electronic test instrumentation, including expanded scale voltmeters and frequency meters, vacuum tube voltmeters, oscillators, resistance bridges, power supplies, wide band amplifiers, WWV receiver, decade inductor and various accessories. Beckman Instruments, Inc. (T-38)

Metal Cutting Band Saws. Descriptive 8 pp catalog gives data and specifications for the complete line of Wells Metal Cutting Band Saws. Also describes automatic bar feed equipment, stock stands and Wells accessories, as well as a blade and speed selection chart for cutting various materials. Wells Manufacturing Co. (T-39)

Machine Tools. 8 pp brochure illustrates automatic multiple-way machine tools designed and built to meet specific production needs. Describes machines used for drilling, reaming, tapping, facing and milling, including tooling drawings, photographs, specification information and estimated production figures. W. F. & John Barnes Co. (T-40)

Measurement and Control Systems. 4 pp illustrated bulletin describes linear variable differential transformer designed to allow sensitive and accurate electrical measurement of small mechanical motions or displacements. It is also adaptable to measurement of force, pressure, weight, stress, flow and other quantities which can be considered in terms of small displacements of calibrated springs, beams and diaphragms. Daytronic. (T-41)

Condensifilters. Illustrated, 4 pp bulletin, M-7155, discusses cleaning and drying of compressed air by the use of an internal condenser in combination with a disposable filter cartridge in a heavy-gauge steel casing. Also included in this bulletin is a moisture-vapor chart which enables evaluation of the water vapor in a compressed air system. Hankison. (T-42)

Rotocycle Meters. Illustrated, 8 pp bulletin OG 409, describes new line of all-bronze Rotocycle meters. The manufacturer recommends this new line for metering alcohols, brine, water, ketones, organic esters, and some mild acids. Rockwell Manufacturing. (T-43)

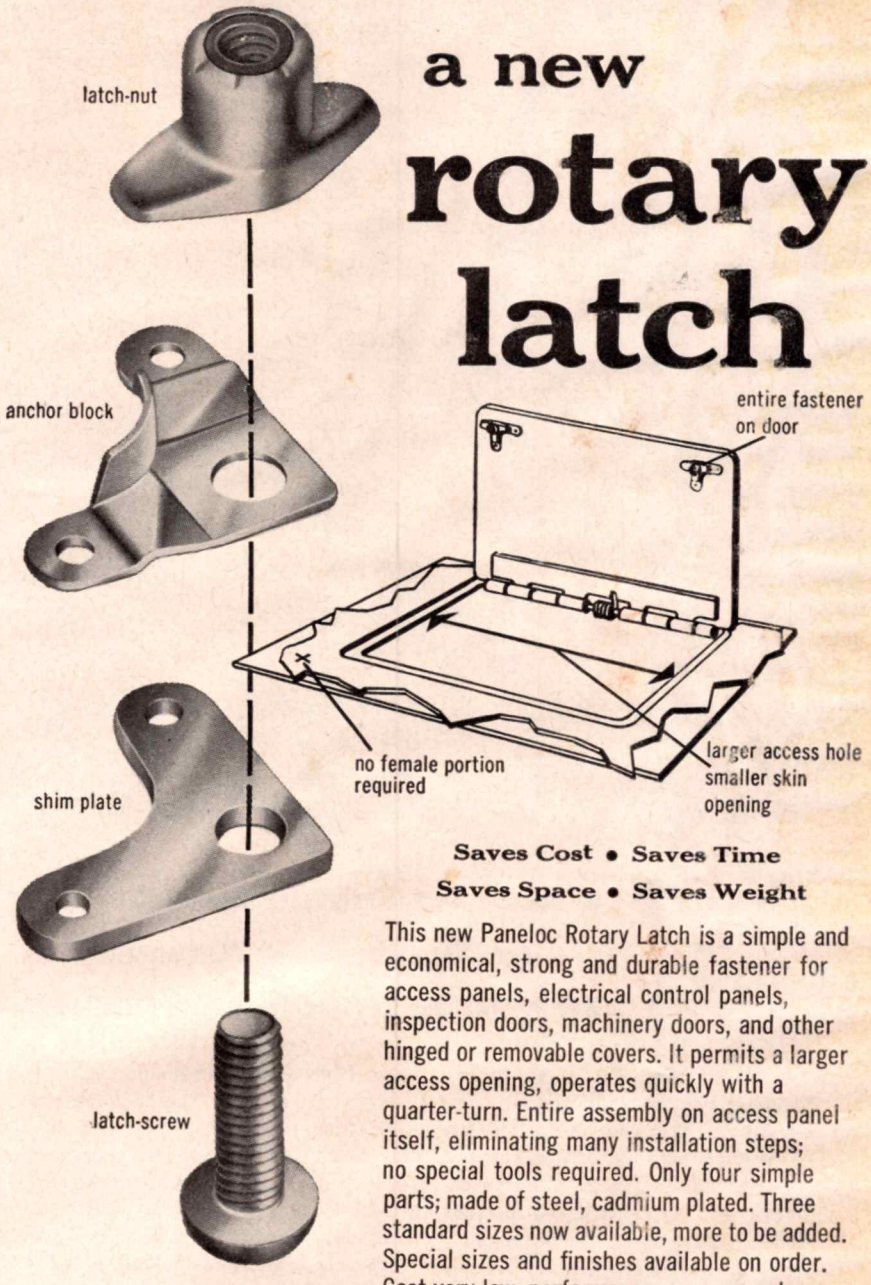
Production Threading. Illustrated 4 pp bulletin 50054, describes new Scru-Broach machine for production threading of large nuts and other internally-threaded parts. The company says this machine has been successfully applied to high production operations where close tolerances must be held, such as the broaching of automotive steering gear ball-race nuts. Ex-Cell-O. (T-44)

Subminiature Relays. 4 pp brochure illustrates subminiature relays designed for a variety of high-precision applications. The Neomite is said to be the world's smallest precision relay, built in a standard transistor case for transistorized circuitry. Elgin-Neomatic. (T-45)

Power-Actuated Tools and Fasteners. 8 pp catalog describes power-actuated tools and fasteners used in construction and maintenance work. Fasteners are shown in full size and are grouped with tool for which they are intended as well as being divided into sections by surface. Olin Mathieson. (T-46)

Connectors. Illustrated 2 pp bulletin CCC20 describes new 37 contact Continental Connector suitable for airborne electronics. Includes electrical and mechanical ratings, mounting and clearance dimensions and diagrams. DeJur-Amsco. (T-47)

PANELOC announces a new rotary latch



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This new Paneloc Rotary Latch is a simple and economical, strong and durable fastener for access panels, electrical control panels, inspection doors, machinery doors, and other hinged or removable covers. It permits a larger access opening, operates quickly with a quarter-turn. Entire assembly on access panel itself, eliminating many installation steps; no special tools required. Only four simple parts; made of steel, cadmium plated. Three standard sizes now available, more to be added. Special sizes and finishes available on order. Cost very low, performance unsurpassed. Write for a catalog and price list for your file.

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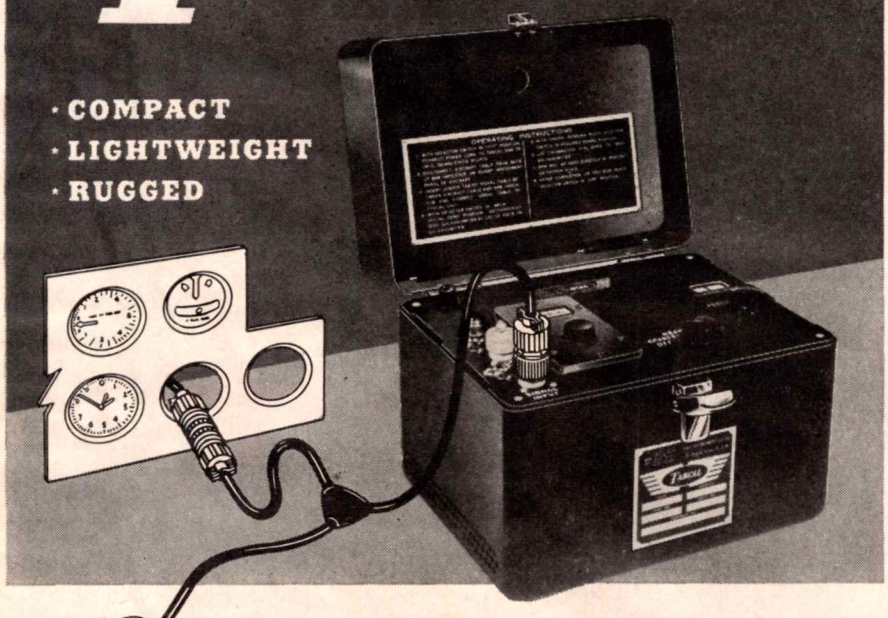

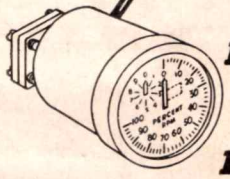

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The new B&H TACKAL incorporates a refinement of the frequency meter principle. It operates in the low (0 to 1000 cps) range, reading the frequency of the tachometer generator on a scale calibrated in percent RPM corresponding to the engine's RPM. In addition the TAKCAL checks the tach system. The TAKCAL circuit and tachometer are parallel so that readings can be made simultaneously to determine the accuracy (or inaccuracy) of the aircraft's tach system. The TAKCAL operates during the engine run to properly set up engine controls for maximum economy and safety.

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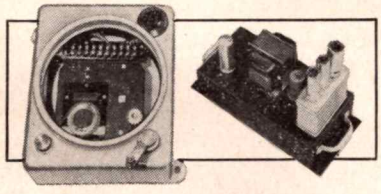

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For further information circle Reader Reply No. 5

Optical Rotary Table. 2 pp circular No. 593, describes new 24 inch precision plain optical rotary table. Easily read projection optical system provides accurate means for precise circular spacing and angular position. Pratt & Whitney. (T-48)

Precision Hole Grinder. 4 pp circular No. 589, describes the number 2E vertical precision hole grinder with built-in depth indicator, dust collector to dispose of grinding dust, telescoping guards to protect carriage and bed ways from scoring or abrasion, centralized controls, 22 x 44 inch table working surface and automatic pressure lubrication. Pratt & Whitney. (T-49)

Pressure Conversion Chart. Bulletin CEC 1557 presents pressure-conversion tables and definitions of pressure-pickup performance. Consolidated Engineering. (T-50)

Counter Altimeter. 4 pp illustrated brochure describes the Kollsman Counter Altimeter, a precision, pressure device designed to present an indication of altitude that may be read easily and without error by the pilot. A low inertia, low friction counter has been developed and produced which indicates altitude in thousands of feet. A pointer indicates the sensitive values on a dial which is graduated in intervals of 50 feet. Kollsman Instrument. (T-51)

Actuators. Data Sheet P99, describes a new series of push button actuators available to designers of electrical computors and other types of commercial and industrial devices requiring reliable panel mounted, manually operated switches. Micro Switch. (T-52)

Gear Cutting Machines. Illustrated 8 pp bulletin SS-55, describes two new high-speed gear cutting machines, Models 18136 and 18206, developed by Michigan Tool Company. Included in the description are dimensional and operational specifications of both models, a discussion of the basic Shear-Speed cutting principle, and a round-up of machine features. Michigan Tool. (T-53)

Dual Purpose Machine. Illustrated, 4 pp bulletin, describes new automatic hydraulic facing unit for use in the machine tool field. With this facing attachment on a boring machine it is now possible to face as well as bore ferrous and non-ferrous materials in a single process. Belock Instrument. (T-54)

Teflon. 4 pp bulletin No. 155 describes various finished, application-engineered Teflon parts for specific uses and needs. The electrical and sealing features combined with high and low temperature range, inertness to nearly all chemicals, low coefficient of friction, and non-adhesive qualities make it a multi-purpose material for a wide range of functions. Sparta Mfg. (T-55)

Carving Wood. 4 pp illustrated bulletin describes Stabilite, a new wood material that remains dimensionally stable. The manufacturer claims that die models and patterns made of Stabilite are unaffected by humidity and temperature change and has a high resistance to acids. Nickey Brothers. (T-56)

Electric Resistance Welding. 12 pp illustrated bulletin No. 3-33, General Machine Catalog, describes industrial applications of mild steel, stainless steel and aluminum as well as a discussion of design, engineering, fabrication, testing, service, installation and maintenance. Specifications are given for spot, rocker arm, seam, roll-spot, special, flash-butt and portable resistance welders and accessories. Sciaky. (T-57)

Submerged Combustion Equipment. 2 pp bulletin, No. 110, describes Thermal submerged combustion equipment. Application of Thermal high velocity burners to submerged combustion techniques offers industry an effective method for heating a liquid, says the manufacturer. Combustion takes place externally to the liquid being heated in this compact equipment. Thermal Research & Engineering. (T-58)

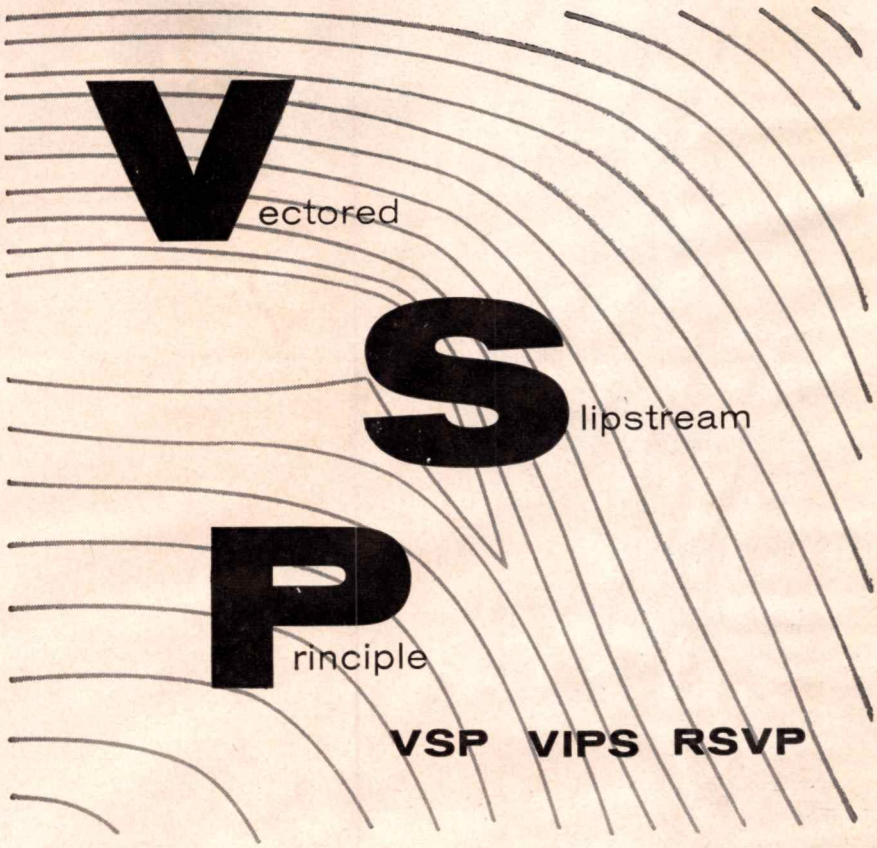
Roller Bearings. 40 pp, illustrated engineering reference manual gives construction dimensions, capacities, housing and tolerance fits on the complete line of Orange staggered roller bearings, full type and cage type needle bearings, journal roller bearings, cam followers, cam yoke rollers and thrust roller bearings. Orange Roller Bearing Co. (T-59)

Automatic Screw Machines. Illustrated, 8 pp bulletin, describes multiple-spindle automatic screw machines, secondary chucking operations, drilling, broaching, centerless grinding, milling, polishing and deburring. Also outlines heat-treating, brazing and welding, plating and anodizing, painting and assembly. Harvey Aluminum. (T-60)

Hole-Punching Equipment. Illustrated 4 pp bulletin, G-1, describes new Unipunch series. A hole-punching equipment for unitized tooling in presses and press brakes. These units punch round and shaped holes up to 1½ inch in diameter in very thin material up to ¼ inch thick mild steel sheets, angles, extrusion, channels and other shaped parts. Punch Products Corp. (T-61)

Deposited Carbon Resistors. Illustrated catalog bulletin B-4a, 4 pp, provides data on tests, applications, specification, tolerance, ranges, performance, dimensions and detailed charts and graphs covering deposited carbon resistors. International Resistance Co. (T-62)

Resistors. 2 pp bulletin, No. 147, gives specifications and features of new Ohmite line of small wirewound, vitreous-enameled resistors with axial leads. Also shows two sizes, rated at 5 and 10 watts, that are carried in stock in a wide range of resistance values. Ohmite Manufacturing Co. (T-63)



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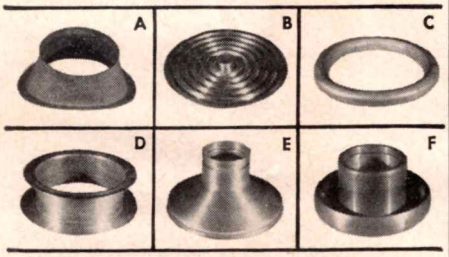
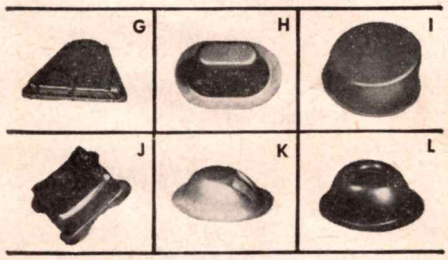


METAL SPINNING AND SPINFORMING:
Typical items: A—Aircraft detail; B—Decorative cover; C—Retainer ring; D—Winding reel; E—Electronic shield; F—Electrical detail.



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Reader Reply No. 40

NEW EQUIPMENT

For further information concerning New Equipment listed below, make use of our Reader Reply Service. You may obtain this information by circling the appropriate number on the Reader Reply Card opposite page 68.

Armored Purge Meter. An armored purge meter, having all-metal construction, is said to give safe metering of any purge fluid. It is designed for use in any chemical or processing installation where purging is required. Fischer & Porter. (E-1)

Timers. Precision timing of short cycle precious metal electroplating. Automatic device works without interruption of current and starts timing automatically when work contact is made. Automatically resets itself when work contact is broken, needing no manual effort after the required time cycle is set. Technic. (E-2)

Auxiliary Power Unit. Electrical and mechanical or hydraulic power is provided for operation of guidance and control systems in guided missles. The Garrett Corporation claims this unit will perform with either a liquid or solid propellant, that burns to generate gas directed against a turbine wheel, mounted on the same shaft as an induction generator rotating at about 24,000 rpm. Output shaft turned by a pinion gear system can operate missile controls mechanically or turn a pump for hydraulic power up to 2.5 hp. (E-3)

Dust Control Unit. Type A hydroprecipitator scrubber removes microscopic solids, fumes and odors from exhaust gases. It can be used anywhere impurities are encountered of extremely low and even submicron size particles, says the Johnson-March Company. This unit collects dust by hydro-compressing exhaust gases through a system of multiple tubes into a water chamber. (E-4)

Amplifier. For use with Norelco scintillation and proportional counters. This unit incorporates a regulated power supply, linear pulse amplifier, amplitude discriminator and three high speed binary counters. Also, provision is made for the addition of a pulse height analyzer. Chassis is enclosed in a separate cabinet and is placed on top of the standard Norelco electronic circuit panel. North American Philips. (E-5)

Separator Filters. Handles Avgas and jet fuel at a rate of 225 gallons per minute while removing about 99 percent solids and 100 percent of the water from the fuel, says Purolator Products. (E-6)

Miniature Connector. Compact and lightweight, the series CCC20 connector is designed to maintain electrical and mechanical functions. Adaptable to airborne electronics, the shells are stainless steel and the flange provides a means of rack, panel, wall or box mounting. DeJur-Amsco. (E-7)

Rubber Sized Fiber. Vulcanized fiber, called type RS-10H rubber sized fiber, uses an oil resistant synthetic rubber sizing. RS-10H combines the properties of both rubber and vulcanized fiber and is claimed by National Vulcanized Fibre to be a possible substitute for rubber coated paper. (E-8)

Heat Detector Cells and Preamplifiers. Used in a remote infrared detection system wherever heat is a factor to be measured and controlled to handle processes in motion where direct contact with the product under control is impossible or inadvisable. The detector cells and preamplifiers require voltages that have been rectified and filtered free of noise and line voltage variations. Servo. (E-9)

Check Valves. ½ inch aluminum alloy check valves for 3000 psi hydraulic service. Model 1008 has external threaded ends that meet government requirements for AN 6249-8 and AN 6207-8. Model 1058 has internal threaded ends, meeting requirements for AN 6280-8. Aircraft Products. (E-10)

Cam Machine. Uses electronics to turn a blueprint into a complex finished product. According to Bendix Aviation this machine will accomplish in two to four hours a technical operation which previously took five to ten weeks. Designed for automatically producing an intricate cam that is the heart of a jet aircraft engine fuel-metering and fuel-control system. (E-11)

Capacitors. One-ended case solid dielectric paper tubular capacitors, designed to meet requirements of printed wiring board assemblies. These Autocon capacitors are enclosed in a pre-molded cylindrical shell of non-flammable thermosetting plastic with the capacitor section sealed against the entrance of moisture by a plastic resin endseal bonded to the phenolic housing. Sprague Electric. (E-12)

Computers. Electronic engineering tool designed to answer highly complex design questions that might take weeks with a slide rule and pencil. This computer helps engineers predict the performance char-

acteristics of a new design under all conditions, even before the actual product is built, says the George A. Philbrick Researchers. (E-13)

Propellers. Four-bladed, turbo-hydromatic type propeller designed to operate through the subsonic and supersonic flight ranges. The Hamilton Standard Division of United Aircraft says the propeller derives its efficiency in different flight ranges through the use of different blade designs. The propeller is attached to the engine, thus relieving the engine nose of the propeller's weight and torque. (E-14)

Nose Cone for Aircraft. Aerodynamically clean fiber-glass-plastic nose cone designed for flush mounting glide-slope and LF antennas. LF antenna is embedded in the plastic itself around nose cone just forward of the mounting holes. Perforations near apex of cone admit air for cabin heating-ventilating system. Lear. (E-15)

Engine Shroud. Titanium engine shroud insulates the jet engine from the surrounding fuselage. Standard smooth sheet stock has been replaced by rigidized titanium and rivets have been replaced by seam and spot welds that, according to Convair, reduces weight. (E-16)

Elapsed Time Indicator. Running time meter, a direct-reading counter, with a synchronous motor drive, in 1½ inch diameter case. Unit is 2¾ inches in length, weighs less than six ounces and uses about two watts of power. It is glass-to-metal hermetic sealed and can be mounted either behind or in front of the mounting panel. Haydon Manufacturing. (E-17)

Receptacles. Series 5049 hermetically sealed receptacles are designed to mate with 50-ohm screw type Microdot coaxial cable plugs. These pressure-tight microminiature coax connectors can also be obtained in 50, 70 and 93 ohm versions. (E-18)

Glazing Materials. Stretched-transparent materials for aircraft glazing applications that require increased toughness and resistance to grazing and fracturing. Stretched acrylic sheeting comes in sizes up to 48 x 48 inches and thicknesses up to ⅜ inch. Swedlow Plastics. (E-19)

Fuel System. Hydro-mechanical fuel balance system that holds cg within one percent of MAC. This is accomplished through automatic sequencing of fuel tanks widely dispersed from the center of gravity. A control unit senses absolute fuel head in forward and aft tanks and feeds these heads into opposing diaphragm chambers at opposite ends of a control valve that operates a shut-off valve between the tanks. Parker Aircraft. (E-20)

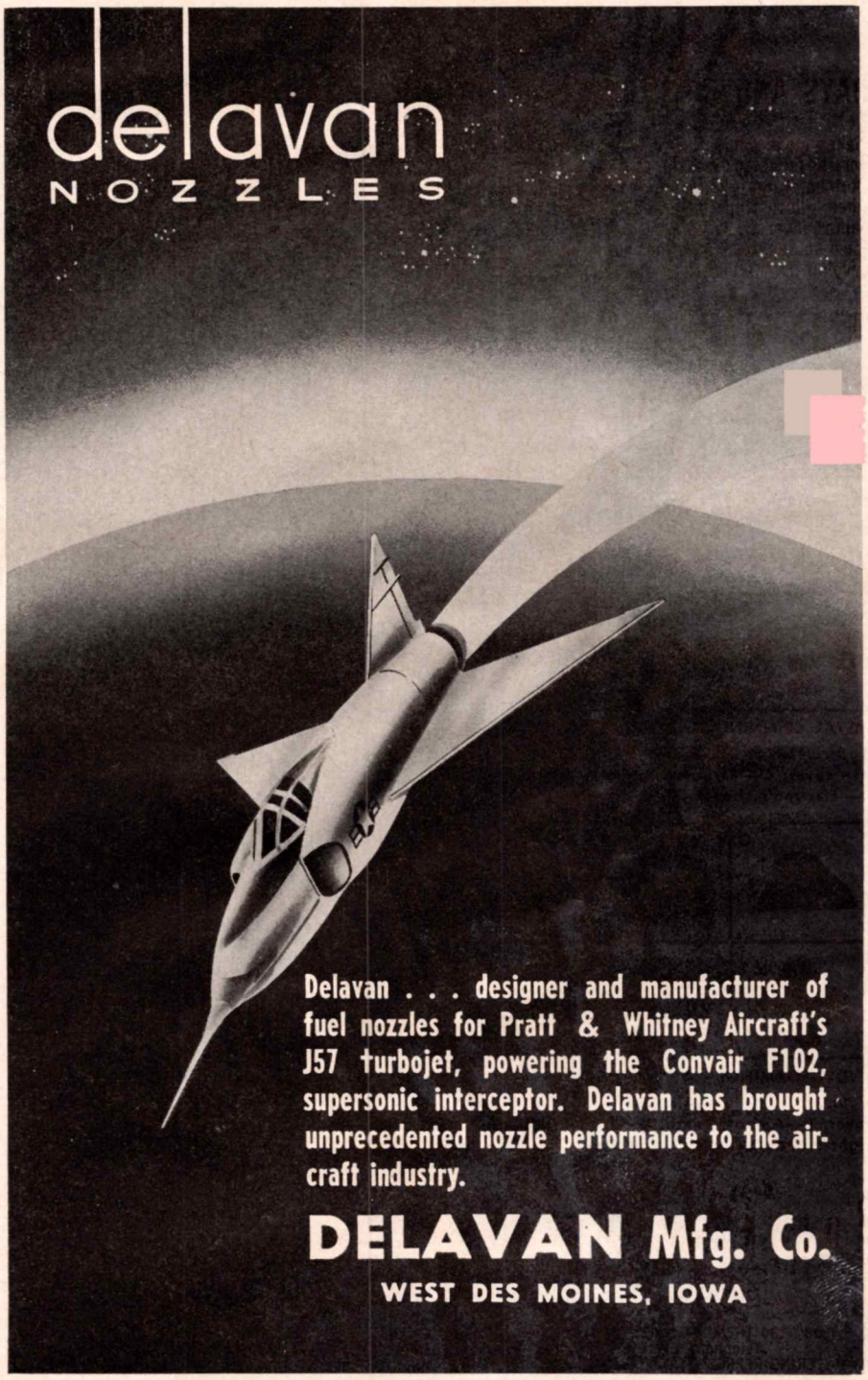
Valves. Resistance flow valve for maintaining constant pressure drops of 7 inches water when inlet pressure fluctuates between 14 inches water and 17 inches water. Also a pressure regulating valve that controls gas pressure at the outlet side when pressure at inlet side varies from 10 inches Hg to 60 inches Hg gage. United Aircraft Products. (E-21)

Power Unit. Miniature power unit that withstands vibrations of 2000 cps at 10 g's. Lear claims that this new mechanism, series 257, provides a remote means of actuation, through flexible drive equipment, for screwjacks, gear boxes and controls. (E-22)

Synchronizer-Power Supply. This unit is designed for the Bendix X-band and C-band airborne weather radar systems. The SYN-1B synchronizer-power supply is 27 pounds lighter than the unit formerly used. (E-23)

Transistorized Fuel Quantity-Balance System. Fuel measuring system contains built-in warning system to show the effect of fuel distribution on an airplane's center of gravity. Combining the electronic functions of fuel quantity and fuel balance indication with a single set of characterized tank units, this unit is said by Minneapolis-Honeywell to be a step toward the development of a fully electronic fuel measuring-fuel distribution control system. (E-24)

Potentiometer. Sub-miniature, wire-wound potentiometer, Model 300-00, possesses amazing electrical and mechanical characteristics despite its small size, says Daystrom. This precision instrument measures 0.500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inch square by 0.187 inch thick and weighs less than two grams. (E-25)

Rate Gyro. Feather-weight subminiature rate gyro with a 1¼ inch diameter by 3¼ inch long envelope has high output signal level, according to Daystrom Pacific. The output signal of the Model 10 is large enough to eliminate redundant amplification equipment usually required for other small size rate gyros. (E-26)

Pressure Regulator and Shutoff Valve. This unit was developed to control a jet engine anti-icing system. Hydro-Aire says the new valve is able to withstand high temperatures and has a combination regulator with shutoff valve in a single unit. (E-27)

Hydraulic Oil Pump. Rotary gear, positive displacement oil pump for aircraft with high volume per weight ratio. This unit is designed by Lear for pumping MIL-0-5606 hydraulic fluid and is claimed to prevent cavitation and turbulence to the pumping area. (E-28)

Exhaust Temperature System. Transistorized system is a hermetically sealed, single indicator-amplifier package, says Minneapolis-Honeywell. This system weighs 0.8 pounds, has a volume of 17 cubic inches and is adaptable to either turbojet or turboprop installations. (E-29)

Spark Plugs. Elbow jet spark plug for gas turbine aircraft engines. AC Spark Plug says this plug is designed in the shape of a 90-degree angle to accommodate limited space between engine and covering, made possible through the development of a process for fabricating a one piece, right angle, insulator, without sacrificing strength. (E-30)

New Lear Autopilot. Republic F-84F fighters which flew 5118 miles nonstop recently from London, England, to Dallas, Texas, were equipped with an advanced-type automatic piloting system developed by Lear, Inc. The jet fighters were flown on autopilot during the entire 10 hour and 58 minute flight except during aerial refueling hook-ups with the KB-29 tanker planes. MB-2 is said to be the most satisfactory automatic flight system ever flown; pilots are impressed with the precision maneuvering possible with the autopilot during formation flying. A new version of the Lear autopilot currently undergoing flight testing will provide new tactical automatic weapons-system tie-ins aimed at further increases in the combat effectiveness of USAF fighters, Lear officials say. (E-40)

Quick-Action Ball-Lok Pins. Production assembly and other types of operations are being speeded up by the adaption of new BALL-LOK pins which embody not only a faster lock and release principle, but an added positive safety lock feature as well, according to the manufacturer, D. W. Price Corporation. BALL-LOK pins are made to military specifications and are single action type, either push or pull, which permits simplicity of operation. BALL-LOK pin cannot be accidentally released. The release button must be depressed to disengage the lock at the time the pin is puled. (E-42)

Tube Fittings, Insulators. Crawford Fitting Company has just released information on the latest addition to the line of **Swagelok** tube fittings, **Swagelok** galvanic insulators of **Zytel** polyamide resin. **Swagelok** galvanic insulators of **Zytel** offer a new method of eliminating galvanic action which results from joining dissimilar metals. With their use, brass, aluminum, copper and steel may now be joined. Moreover, they will find many applications at junction boxes, panel boards and bulkheads, manufacturer says. **Swagelok** galvanic insulators of **Zytel** are made in a complete line of shapes and in 1/16 inch to 1 inch tube and pipe sizes. (E-43)

Hot Fuel Priming Device. A new hot fuel priming device which makes three-minute starts a reality for large aircraft piston engines in the worst of Arctic or Antarctic temperatures has been developed by Janitrol Aircraft-Automotive Division.

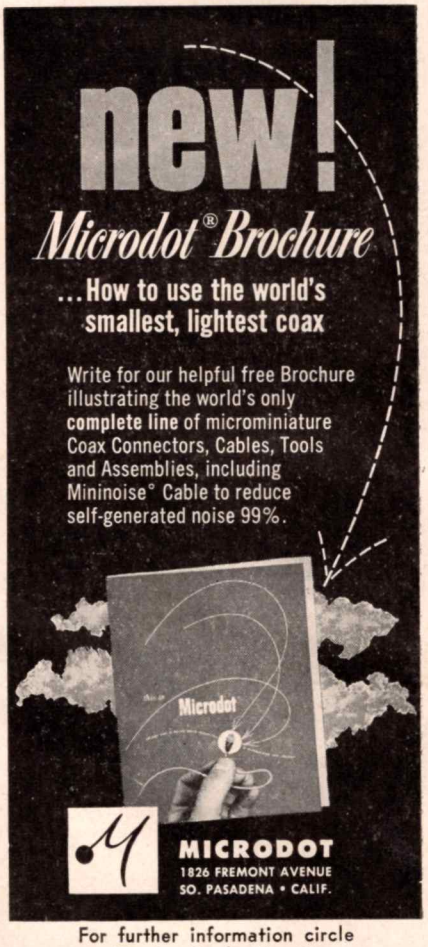
The unit, built to conform with military specifications, enables the pilot to have an engine firing within 60 seconds, even after a 72-hour cold soak at —65 degrees Fahrenheit, by continuously delivering 200-degree gasoline to the cylinders. In another two minutes, the engine is running free and clear.

The priming unit, which weighs less than 16 pounds, is made up of a burner and a sealed heat exchanger. The latter includes twin coils of quarter-inch stainless steel tubing carrying the gasoline being heated through the burner chamber.

The burner, using gasoline bled off the fuel line at a rate of two to three quarts an hour, is ignited by a spark plug. With the comparatively large surface area of the tubing exposed to the 600-degree flame, heating is instantaneous and continuous as the engine fuel flows through.

When the engine fuel reaches the pre-set temperature of 200 degrees, the engine starter is automatically actuated. An automatic thermal cycling switch, by opening and closing solenoid burner supply valves, maintains the temperature of the gasoline flowing through the coil until the engine has built up its own heat and is running free and clear. Another thermal switch prevents overheating by cutting the burner out when the fuel temperature reaches 220 degrees. (E-45)

Aircraft Heating. A complete line of heating equipment for business and corporate owned aircraft is offered by the Janitrol Aircraft-Automotive Division of Surface Combustion Corporation, Columbus, Ohio. The equipment is designed specifically to meet heating needs for all aircraft types in the field of business flying. It includes, together with accessories, models for smaller ships on up to the largest airliners. The models used singly, in combination or in multiples can supply the heating comfort requirements of practically any size business aircraft, according to the manufacturer. (E-46)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ABSTRACTS

Harvey G. McComb, Jr., and Emmet F. Low, Jr., COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL STRESSES IN CIRCULAR SEMI-MONOCOQUE CYLINDERS WITH RECTANGULAR CUTOUTS, NACA TN 3544, National Advisory Committee for Aeronautics, Washington, October 1955.

Comparisons are made between a theory for calculating stresses about rectangular cutouts in circular cylinders of semimonocoque construction published in NACA TN 3200 and previously published NACA experimental data. The comparisons include stresses in the stringers and shear stresses in the center of the shear panel in the neighborhood of the cutout. The theory takes into account the bending flexibility of the rings in the structure, and this factor is found to be important in the calculation of stresses about cutouts. In general, when the ring flexibility is considered, good agreement is exhibited between the calculated and experimental results.

William H. Sterbentz and Joseph Davids, AMPLITUDE OF SUPERSONIC DIFFUSER FLOW PULSATIONS, NACA TN 3572 (formerly RM E52124), National Advisory Committee for Aeronautics, Washington, October 1955.

A theoretical method for evaluating the stability characteristics and the amplitude and frequency of pulsation of ram-jet engines without heat addition is presented. Theory and experiment show that the pulsation amplitude of a high-mass-flow-ratio diffuser increases with decreasing mass flow. The theoretical trends for changes in amplitude, frequency, and mean pressure recovery with changes in plenum-chamber volume were experimentally confirmed. For perforated, convergent-divergent-type diffusers, theory and experiment show the existence of a stability hysteresis loop on the pressure-recovery, mass-flow-ratio curve.

Warren J. North and Willard D. Coles, EFFECT OF EXHAUST-NOZZLE EJECTORS ON TURBOJET NOISE GENERATION, NACA TN 3573, National Advisory Committee for Aeronautics, Washington, October 1955.

Engine noise levels and jet velocity profiles have been obtained with several turbojet exhaust-nozzle ejectors. An insignificant reduction in total sound power was realized. At subsonic nozzle pressure ratios, total sound power from exhaust-nozzle ejectors or bypass exit configurations can be calculated from primary-jet parameters only.

Franklin W. Diederich and Martin Zlotnick, CALCULATED SPANWISE LIFT DISTRIBUTIONS AND AERODYNAMIC INFLUENCE COEFFICIENTS FOR SWEPT WINGS IN SUBSONIC FLOW, NACA TN 3476, National Advisory Committee for Aeronautics, Washington, October 1955.

Spanwise lift distributions have been calculated for 61 swept wings with various aspect ratios and taper ratios and with a variety of angle-of-attack or twist distributions, including flap and aileron deflections, by means of the Weissinger method with eight control points on the semispan. Also calculated were aerodynamic influence coefficients which pertain to a certain definite set of stations along the span.

Stanley H. Scher, PILOT'S LOSS OF ORIENTATION IN INVERTED SPINS, NACA TN 3531, National Ad-

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visory Committee for Aeronautics, Washington, October 1955.

The rising problem of pilot orientation during spins, especially during unintentional inverted spins, is discussed. The free-spinning-tunnel results and reported airplane experiences concerning inverted spins and recoveries are reviewed. Information is provided regarding the nature of inverted spins, optimum control technique for recovery, and some of the factors which apparently contribute to the pilot's loss of orientation. A spin-simulator rig which was recently constructed at the Langley Laboratory for use in an attempt to understand better the problems confronting the pilot of a spinning airplane is described.

L. H. Donnell and V. C. Tsien, A UNIVERSAL COLUMN FORMULA FOR LOAD AT WHICH YIELDING STARTS, NACA TN 3415, National Advisory Committee for Aeronautics, Washington, October 1955.

Ananalysis is presented of the load at which yielding first occurs in actual columns, taking adequately into account all the factors which have an important effect upon this load. The results are expressed as a formula or chart applicable to all cases.

Donald S. Woolston, Harry L. Runyan and Thomas A. Byrdsong, SOME EFFECTS OF SYSTEM NONLINEARITIES IN THE PROBLEM OF AIRCRAFT FLUTTER, NACA TN 3539, National Advisory Committee for Aeronautics, Washington, October 1955.

This paper presents the results of a preliminary investigation of the effect of nonlinear structural terms on the flutter of a two-degree-of-freedom system. The three types of nonlinearities investigated were a flat spot, hysteresis, and a cubic spring. Calculations were made on an analog computer. For one case, the flat spot, an experimental investigation was also made and good correlation with theory was found.

William S. Aiken, Jr. and Bernard Wiener, ANALYSIS OF THE HORIZONTAL-TAIL LOADS MEASURED IN FLIGHT ON A MULTIENGINE JET BOMBER, NACA TN 3479, National Advisory Committee for Aeronautics, Washington, September 1955.

Horizontal-tail loads were measured in gradual and abrupt longitudinal maneuvers on two configurations of a four-engine jet bomber. The results obtained have been analyzed to determine the flight value of the coefficients important in calculations of horizontal tail loads. The least-squares procedure used to determine aerodynamic tail loads from strain-gage measurements of structural tail loads which were affected by temperature is covered in detail. The effect of fuselage flexibility on the airplane motion is considered in the analysis of the abrupt-maneuver data. When possible, wind-tunnel results are compared with flight results. Some calculations of critical horizontal-tail loads beyond the range of the tests are given and compared with design loads.

W. G. Hample, FRICTION STUDY OF AIRCRAFT TIRE MATERIAL ON CONCRETE, NACA TN 3294, National Advisory Committee for Aeronautics, Washington, September 1955.

A systematic study was made of the variation of frictional resistance between typical tire-tread material and three concrete surfaces of different roughness at various temperatures and normal pressures. The tire-tread specimens were taken from the thickest portion of worn ten-ply tires, and the three concrete test blocks were poured from the same mix but subjected to different surface finishes. Curves are presented of the apparent coefficient of friction as a function of normal pressure.

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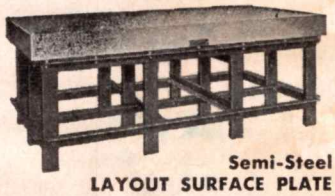

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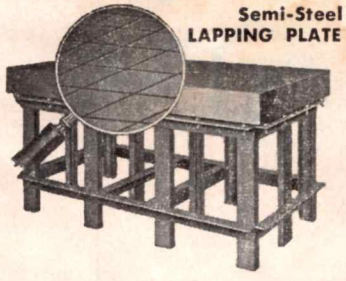

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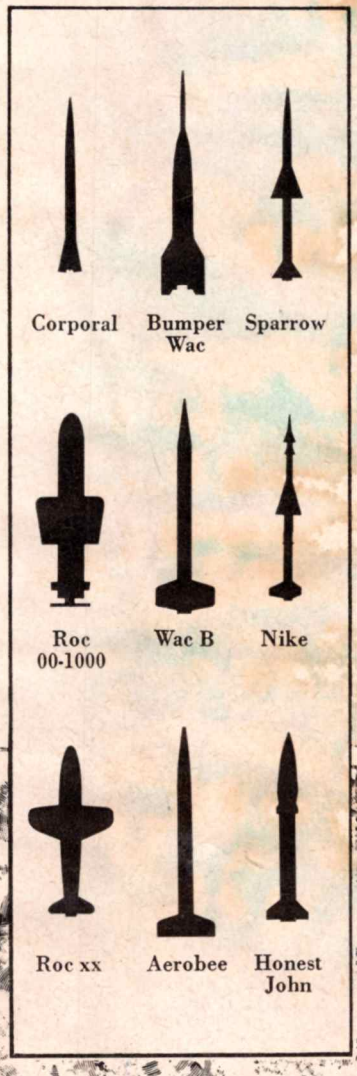

Growing importance of missiles in the nation's defense has led to the separation of missiles engineering from aircraft engineering functions at Douglas Aircraft Company.

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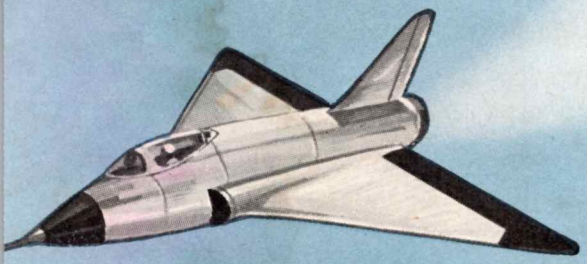

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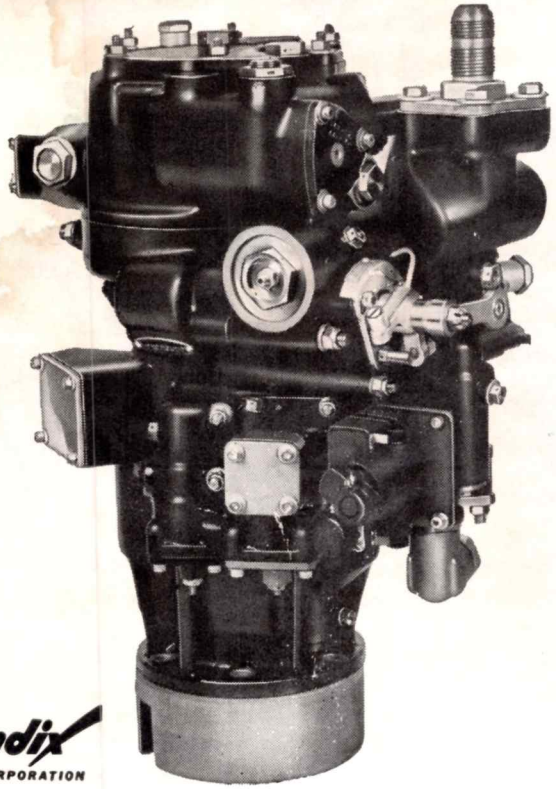

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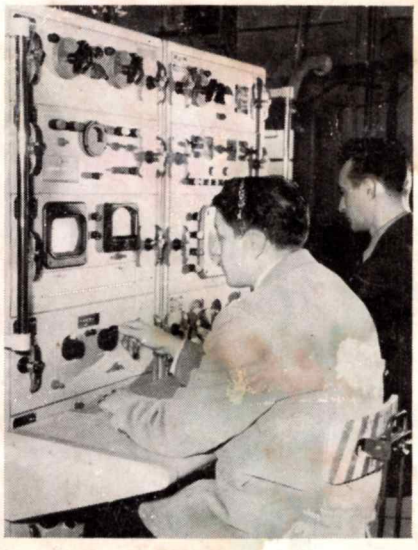

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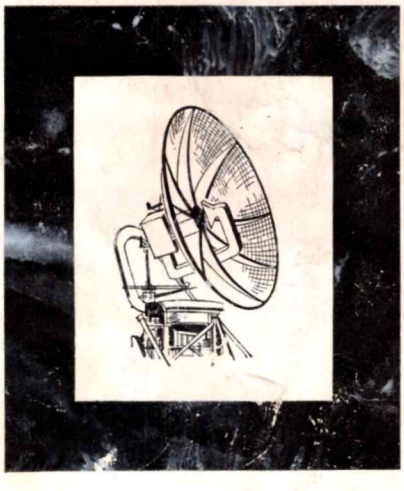

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